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Prevalence, Causes, and Prevention Strategies of Medication Errors in Nursing Practice in Iraqi Teaching Hospitals: A Mixed-Methods Study

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ABSTRACT
Background: Medication errors are a leading preventable cause of patient harm worldwide and remain under-characterized in Iraqi teaching hospitals, particularly through approaches that triangulate documented incident data with frontline nurse perspectives. Aim: To estimate the documented prevalence of medication errors and characterize their causes and proposed prevention strategies in three Iraqi teaching hospitals using a mixed-methods approach. Methods: A sequential explanatory mixed-methods study was conducted between October 2024 and February 2026, reporting in line with the Good Reporting of A Mixed Methods Study (GRAMMS) framework [1] and the STROBE statement [2] for the quantitative components. The protocol was prospectively registered (ATU-RIR-2025-09, registered 4 August 2025). Phase 1 was a 12-month retrospective review of all formally reported medication-error incident reports (n = 480) across the medical–surgical, intensive care, and emergency wards of three teaching hospitals (Salah Al-Din, Baghdad, Kirkuk). Each event was classified by stage in the medication-use process (prescribing, transcription, dispensing, administration, monitoring), by error type, by NCC MERP severity index (Categories A–I), and by Reason's Swiss-Cheese contributory factors. Phase 2 was a cross-sectional survey of 350 ward nurses (320 complete responses, 91.4%) using a structured 56-item instrument covering perceived causes, reporting behavior, and prevention strategies. Phase 3 integrated quantitative findings against the nurse-reported causes to produce a hospital-level prevention roadmap. Results: The documented medication-error rate was 8.4 per 1,000 patient-days (95% CI 7.7–9.2). By stage, 41.0% of errors originated in prescribing/transcription, 38.1% in administration, 12.5% in dispensing, and 8.4% in monitoring. Wrong-dose (28.5%), wrong-time (21.0%), and omitted-dose (16.5%) were the most common error types. NCC MERP severity distribution was: Category A–B 30.4%, C–D 56.0%, E–F 11.7%, G–I 1.9% (no fatal events were captured). Nurse-reported leading causes were heavy workload (78.4%), distractions during administration (71.9%), look-alike/sound-alike packaging (68.4%), illegible prescriptions (62.5%), and lack of double-check protocols (54.7%). Of nurses, 52.2% reported having witnessed unreported errors in the prior six months; the principal deterrents were fear of disciplinary action (61.3%) and perceived lack of feedback on submitted reports (54.7%). Conclusion: Medication errors in Iraqi teaching hospitals occur at rates comparable to international benchmarks, with most events of low-to-moderate severity but with substantial under-reporting and a clear concentration of contributory factors at the workload, packaging, prescription-legibility, and double-check-protocol levels. A hospital-level prevention roadmap should prioritize a non-punitive reporting culture, structured double-check protocols for high-alert medications, packaging-driven distinguishability of look-alike products, and protected medication-administration time.

KEYWORDS ***Safety;*** *Nursing; Iraq; Risk Management, Healthcare; Mixed-Methods Research*

1-INTRODUCTION

Medication errors are among the most frequent preventable causes of patient harm in modern healthcare, with the World Health Organization estimating an annual global cost of approximately USD 42 billion in avoidable hospital expenditure attributable to such errors [3]. Beyond the financial burden, medication errors are associated with prolonged length of stay, additional clinical interventions, patient and family distress, and—in their most severe forms—permanent disability or death. Within the medication-use process, errors can occur at any of five sequential stages (prescribing, transcription, dispensing, administration, and monitoring), and contemporary patient-safety thinking has moved decisively from a person-focused view of error toward a systems-focused view rooted in James Reason's Swiss-Cheese model, in which active failures by frontline staff align transiently with latent organizational holes to produce harm [4,5].

Iraqi teaching hospitals operate under cumulative system-level pressures—heavy and uneven workloads, intermittent medication supply, partial electronic prescribing, varying ward-level adoption of double-check protocols, and limited investment in structured incident-report feedback to staff—that are each plausibly associated with elevated medication-error risk [6,7]. Earlier Iraqi reports have suggested high rates of nurse-perceived medication errors and substantial under-reporting in single-site samples [8,9], but multi-site studies

that triangulate formally documented incident data with nurse perspectives, classify events using a standard severity framework (the National Coordinating Council for Medication Error Reporting and Prevention Index, NCC MERP), and integrate findings within an organizational-systems theoretical framework remain limited. Without such evidence, hospital leadership lacks the basis required to choose between competing intervention options—non-punitive reporting culture change, double-check protocols, packaging-driven distinguishability, protected administration time, and electronic prescribing—each of which has different implementation cost and feasibility profiles.

We therefore designed a sequential explanatory mixed-methods study in three Iraqi teaching hospitals with the explicit goals of (i) estimating the documented medication-error rate over a 12-month period and characterizing the distribution of errors by stage, type, and NCC MERP severity; (ii) characterizing the nurse-reported leading causes, reporting behavior, and proposed prevention priorities through a structured cross-sectional survey; and (iii) integrating both data sources within Reason's Swiss-Cheese model to produce a hospital-level prevention roadmap. The study reports in line with the GRAMMS framework for mixed-methods studies and the STROBE statement for the quantitative components.

2. MATERIALS AND METHODS

2.1 Study Design, Setting, and Reporting

We conducted a sequential explanatory mixed-methods study comprising a quantitative retrospective incident-report review (Phase 1) followed by a quantitative cross-sectional nurse survey (Phase 2), with explicit integration anchored to Reason's Swiss-Cheese model (Phase 3). Both phases were conducted between October 2024 and February 2026 across the medical–surgical, intensive care, and emergency wards of three government teaching hospitals in central Iraq: Salah Al-Din General Teaching Hospital, Baghdad Teaching Hospital, and Kirkuk General Teaching Hospital. Reporting follows the Good Reporting of A Mixed Methods Study (GRAMMS) framework [1] and the STROBE statement [2] for cross-sectional studies. The protocol, statistical analysis plan, and outcome definitions were prospectively registered in the the Al-Turath University Research Implementation Registry (ATU-RIR-2025-09, registered 4 August 2025) before data collection began.

2.2 Phase 1: Retrospective Incident-Report Review

All formally documented medication-error incident reports filed in the participating hospitals' incident-reporting systems between 1 January and 31 December 2024 were retrieved from the central nursing-administration archives. To be eligible for inclusion, a report had to (i) describe an event involving medication ordering, transcription, dispensing, administration, or monitoring; (ii) involve a hospitalized patient in one of the three target ward types; and (iii) contain sufficient narrative detail to allow severity classification. Reports relating to outpatient settings, reports lacking essential narrative elements, and duplicate reports of the same event were excluded. The denominator (patient-days) for the 12-month period was obtained from each hospital's bed-occupancy registry.

Each included incident report was independently classified by two trained reviewers using a structured abstraction form covering: (a) stage in the medication-use process (prescribing, transcription, dispensing, administration, monitoring); (b) error type (wrong-dose, wrong-drug, wrong-time, omitted-dose, wrong-route, wrong-patient, wrong-rate, allergy violation, other); (c) National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) severity index, which classifies events into nine categories from A (no error, capacity to cause error) through I (error contributing to or resulting in patient death) [10]; and (d) primary contributory factor mapped onto Reason's Swiss-Cheese model categories (organizational, supervisory, preconditions for unsafe acts, unsafe acts) [4,5]. Discrepancies between reviewers were resolved by consensus discussion. Inter-rater agreement on independent reclassification of 50 randomly selected reports was Cohen's kappa = 0.81 for stage and 0.76 for NCC MERP category.

2.3 Phase 2: Cross-Sectional Nurse Survey

Eligible participants for the survey component were registered nurses with at least six months of continuous experience on a medical–surgical, ICU, or emergency ward at one of the three participating hospitals. Sample-size calculation assumed a target proportion of nurse-perceived major causal factors of 0.50, a margin of error of 0.06, and a 95% confidence level, yielding a minimum required sample of 268; this was inflated to 350 to allow for non-response and ward-stratified analysis. Stratified proportional sampling was applied across hospitals and ward types.

The 56-item survey instrument was developed in four sections: (a) demographic and occupational characteristics (10 items); (b) perceived prevalence and severity of medication errors observed in the prior six months (8 items); (c) perceived causes (24 items rated on a 5-point Likert scale, organized by Reason's Swiss-

Cheese categories: organizational, preconditions, unsafe acts), drawing on the Medication Administration Error Reporting Survey [11]; and (d) reporting behavior, deterrents, and prevention strategy preferences (14 items). Content validity was established by an expert panel of five reviewers (two patient-safety academics, two senior clinical nurses, one hospital pharmacist), with a scale-level content validity index (S-CVI/Ave) of 0.92. The instrument was forward- and back-translated between English and Arabic by two independent bilingual translators. A pilot study in 35 nurses (not included in the main analysis) yielded a Cronbach's α of 0.88 for the perceived-causes scale.

2.4 Phase 3: Integration

Quantitative results from Phase 1 (frequency distribution of error stage, type, severity, and contributory factor) and Phase 2 (nurse-reported causes and prevention preferences) were integrated within Reason's Swiss-Cheese framework. The integration sought, for each of the four Swiss-Cheese layers (organizational influences, supervisory factors, preconditions for unsafe acts, unsafe acts), to identify the most prevalent contributory factors evidenced by both data sources, and to derive a prioritized hospital-level prevention roadmap whose recommendations are grounded in convergence between documented events and frontline perspectives.

2.5 Ethical Considerations and Registration

The study was approved by the Research Ethics Committee of Al-Turath University (approval ATU-RE-2025-152) and by the local research and patient-safety committees of each participating hospital. For Phase 1, access to incident-report data was provided in aggregated, de-identified form under a data-sharing agreement; no patient or staff identifiers were retained on the abstraction database. For Phase 2, written informed consent was obtained from every nurse, and survey responses were stored on encrypted institutional servers. The protocol was prospectively registered (ATU-RIR-2025-09, 4 August 2025). Because incident reporting is a sensitive subject, the survey explicitly stated that participation would not affect employment standing, and an institutional reporting-improvement objective was disclosed at consent. The study followed the Declaration of Helsinki principles.

2.6 Statistical Analysis

Continuous variables are presented as mean ± SD, and categorical variables as frequencies and percentages. The medication-error rate per 1,000 patient-days is reported with a 95% confidence interval computed using the Poisson exact method. Proportions of error stage, type, severity, and contributory factor are reported with 95% confidence intervals computed using the Wilson score method. Bivariate associations between hospital and error characteristics used the chi-square test. Multivariable binary logistic regression with cluster-robust standard errors at the hospital level was used to identify nurse-level factors associated with having witnessed an unreported error in the prior six months. Survey-derived perceived-cause endorsement rates were ranked by mean Likert score and integrated against the Phase 1 contributory-factor distribution. Two-sided p-values < 0.05 were considered statistically significant. Analyses used SPSS version 27 (IBM Corp., Armonk, NY) and R version 4.3.2 (R Foundation, Vienna, Austria).

3. RESULTS

3.1 Phase 1: Documented Medication-Error Rate, Stage, Type, and Severity

Across the three participating hospitals, 480 medication-error incident reports met the inclusion criteria over the 12-month period (Salah Al-Din 168, Baghdad 184, Kirkuk 128). The aggregate denominator was 57,142 patient-days. The overall documented medication-error rate was therefore 8.4 per 1,000 patient-days (95% CI 7.7–9.2), with hospital-level variation ranging from 7.1 to 9.7 per 1,000 patient-days ($\chi^2 = 6.84$, $p = 0.033$). Stage, error type, and NCC MERP severity distributions are summarized in Table 1.

By stage in the medication-use process, prescribing and transcription combined accounted for 41.0% of all errors, administration for 38.1%, dispensing for 12.5%, and monitoring for 8.4%. By error type, wrong-dose was the most common (28.5%), followed by wrong-time (21.0%), omitted-dose (16.5%), wrong-drug (10.6%), and wrong-route (8.1%). The NCC MERP severity distribution showed that 30.4% of events were Category A–B (no error or error reaching the patient without harm), 56.0% Category C–D (error reaching the patient without harm or with monitoring required), 11.7% Category E–F (temporary harm requiring intervention or initial/prolonged hospitalization), and 1.9% Category G–I (permanent harm or contributing to patient death). No fatal events were captured in the dataset over the 12-month review window.

Table 1. Phase 1: Distribution of 480 medication errors by stage, type, and NCC MERP severity (12-month review).

Item	n (%)	95% CI / category meaning
Total documented errors	480 (100)	8.4 per 1,000 patient-days (7.7–9.2)
Stage: Prescribing	118 (24.6)	21.0–28.6
Stage: Transcription	79 (16.5)	13.4–20.0
Stage: Dispensing	60 (12.5)	9.8–15.8
Stage: Administration	183 (38.1)	33.9–42.6
Stage: Monitoring	40 (8.4)	6.2–11.2
Type: Wrong-dose	137 (28.5)	24.7–32.7
Type: Wrong-time	101 (21.0)	17.6–24.9
Type: Omitted-dose	79 (16.5)	13.4–20.0
Type: Wrong-drug	51 (10.6)	8.2–13.7
Type: Wrong-route	39 (8.1)	6.0–10.9
Type: Wrong-patient	27 (5.6)	3.9–8.0
Type: Allergy violation / wrong-rate / other	46 (9.6)	7.2–12.6
NCC MERP A–B (no harm/no reach)	146 (30.4)	26.5–34.7
NCC MERP C–D (reached patient, no/minor harm)	269 (56.0)	51.6–60.4
NCC MERP E–F (temporary harm; intervention)	56 (11.7)	9.1–14.9
NCC MERP G–I (permanent harm to death)	9 (1.9)	1.0–3.5

Note: *NCC MERP = National Coordinating Council for Medication Error Reporting and Prevention severity index [10]: Category A (capacity to cause error), B (error did not reach patient), C (reached patient without harm), D (reached patient, monitoring required), E (temporary harm with intervention), F (initial or prolonged hospitalization), G (permanent harm), H (life-threatening intervention required), I (death). Wilson score method was used for the 95% CIs of proportions; the rate per 1,000 patient-days uses the Poisson exact 95% CI. Hospital-level variation in rate was 7.1–9.7 per 1,000 patient-days ($\chi^2 = 6.84$, $p = 0.033$).*

3.2 Phase 2: Nurse-Reported Causes and Reporting Behavior

Of 350 nurses approached for the cross-sectional survey, 320 returned complete responses (response rate 91.4%; demographic profile in Table 2). Most respondents were women (74.7%), held a Bachelor's degree (62.5%), and had at least three years of ward experience (66.6%). The most highly endorsed perceived causes of medication errors (mean Likert ≥4.0 of 5) were heavy workload (4.21), distractions during administration (4.09), look-alike/sound-alike packaging (3.98), illegible prescriptions (3.86), and lack of double-check protocols (3.71); detailed endorsement rates are summarized in Table 3. Lower-endorsed causes (mean Likert ≤3.5) included nurse education level and individual fatigue, suggesting that nurses themselves attribute most error risk to system-level factors rather than to personal limitations.

Table 2. Phase 2: Demographic and occupational characteristics of the 320 nurses surveyed.

Characteristic	n (%) or mean ± SD	Range / categories
Age (years)	32.1 ± 7.3	21–58
Sex: Female	239 (74.7)	—
Sex: Male	81 (25.3)	—
Education: Diploma	92 (28.8)	—
Education: Bachelor's degree	200 (62.5)	—
Education: Master's degree	28 (8.7)	—
Total nursing experience (years)	8.2 ± 5.5	1–30
Years on current ward	4.1 ± 3.0	0.5–17
Years on current ward ≥3	213 (66.6)	—
Ward: Medical–surgical	146 (45.6)	—
Ward: Intensive care unit	94 (29.4)	—
Ward: Emergency department	80 (25.0)	—
Witnessed unreported error in past 6 months	167 (52.2)	—
Self-reported personal medication error in past 6 months	62 (19.4)	—
Prior structured medication-safety training (24 mo)	108 (33.8)	—
Hospital: Salah Al-Din	112 (35.0)	—
Hospital: Baghdad	118 (36.9)	—
Hospital: Kirkuk	90 (28.1)	—

Note: *SD = standard deviation. "Witnessed unreported error" was operationalized as having seen at least one medication error that was not formally reported through hospital systems in the prior 6 months. Education category percentages do not sum to 100 due to rounding.*

Reporting behavior data were striking. Of the 320 surveyed nurses, 167 (52.2%) had witnessed at least one medication error in the prior six months that was not formally reported, and 62 (19.4%) acknowledged having personally made at least one medication error in the same period. Among those who had witnessed unreported errors, the principal stated deterrents to reporting were fear of disciplinary action (61.3%), perceived lack of feedback on submitted reports (54.7%), perception that the error was "not serious enough to report" (43.0%), and lack of a clear reporting pathway (29.6%). When asked to rank prevention priorities, respondents most commonly endorsed (i) institution of structured double-check protocols for high-alert medications (78.1%), (ii) packaging-driven distinguishability of look-alike products (72.5%), (iii) protected medication-administration time free of non-urgent interruptions (68.4%), (iv) electronic prescribing (62.8%), and (v) regular feedback to staff on reported events (59.7%).

Table 3. Phase 2: Nurse-perceived causes of medication errors and convergence with Phase 1 contributory factors.

Perceived cause (Phase 2)	Mean Likert (1–5)	% endorsing (≥4)	Phase 1 convergence
Heavy workload / understaffing	4.21	78.4	Yes — administration-stage errors concentrated in high-occupancy wards
Distractions during administration	4.09	71.9	Yes — 38% of errors at administration stage
Look-alike / sound-alike packaging	3.98	68.4	Yes — wrong-drug errors 10.6%
Illegible prescriptions	3.86	62.5	Yes — prescribing/transcription 41% of all errors
Lack of double-check protocols	3.71	54.7	Partial — concentrated in high-alert medications
Lack of structured medication-safety training	3.62	47.2	Indirect — captured via nurse-level predictors
Communication gaps between shifts	3.54	44.1	Yes — handoff errors documented in 9% of cases
Insufficient pharmacy decision support	3.48	39.7	Indirect
High medication-stock turnover	3.32	36.6	Partial
Nurse fatigue from night shifts	3.41	38.1	Indirect — captured via individual factors
Individual education level	2.84	21.3	No direct convergence

Note: *Mean Likert scores are calculated across all 320 surveyed nurses on a 5-point scale (1 = strongly disagree, 5 = strongly agree). "% endorsing" is the percentage of nurses rating the cause 4 or 5. "Phase 1 convergence" indicates whether the cause is supported by the documented incident-report distribution ("Yes"), partially supported ("Partial"), supported indirectly through individual-level factors ("Indirect"), or without direct evidence in Phase 1 ("No").*

3.3 Predictors of Witnessing Unreported Errors

Adjusted estimates from the multivariable logistic regression of having witnessed an unreported error in the prior six months are summarized in Table 4. After mutual adjustment and with cluster-robust standard errors at the hospital level, three nurse-level factors independently predicted having witnessed unreported errors: perception of a punitive incident-reporting culture (aOR 2.85, 95% CI 1.78–4.56, $p < 0.001$), absence of prior structured medication-safety training (aOR 1.96, 1.27–3.02, $p = 0.002$), and ≥3 years of experience on the current ward (aOR 1.84, 1.18–2.86, $p = 0.007$), the latter most plausibly reflecting longer cumulative observational exposure rather than ward-tenure causality. The model showed acceptable discrimination (apparent c-statistic 0.74, 95% CI 0.68–0.80; optimism-corrected 0.72 by 1000 bootstrap replications) and adequate calibration (Hosmer–Lemeshow $\chi^2 = 7.42$, $p = 0.491$). Variance inflation factors were all below 1.6.

Table 4. Multivariable logistic regression of factors associated with having witnessed an unreported medication error in the prior 6 months (n = 320).

Predictor	Adjusted OR	SE (log)	95% CI	p-value
Perceived punitive reporting culture	2.85	0.24	1.78 to 4.56	<0.001*
No prior medication-safety training (24 mo)	1.96	0.22	1.27 to 3.02	0.002*
≥3 years on current ward	1.84	0.22	1.18 to 2.86	0.007*
Ward: ICU (vs medical–surgical)	1.41	0.22	0.92 to 2.16	0.116
Ward: Emergency (vs medical–surgical)	1.27	0.23	0.81 to 1.99	0.301
Female sex	1.13	0.23	0.72 to 1.78	0.591
Master's degree	0.78	0.27	0.46 to 1.32	0.353
Total nursing experience (per year)	0.99	0.05	0.90 to 1.09	0.842
Self-reported own error in past 6 months	1.45	0.24	0.91 to 2.31	0.118

Note: *OR = odds ratio; CI = confidence interval. Adjusted ORs are from a single multivariable binary logistic regression model with cluster-robust standard errors at the hospital level. * $p < 0.05$. Apparent c-statistic 0.74 (95% CI 0.68–0.80); optimism-corrected c-statistic 0.72 by 1000 bootstrap replications. Hosmer–Lemeshow goodness-of-fit $\chi^2 = 7.42$, $p = 0.491$. All variance inflation factors <1.6. The dependent variable is having witnessed at least one medication error not formally reported through hospital systems in the prior 6 months.*

4. DISCUSSION

This sequential explanatory mixed-methods study—combining a 12-month review of 480 documented incident reports with a parallel cross-sectional survey of 320 ward nurses—provides four principal findings. First, the documented medication-error rate of 8.4 per 1,000 patient-days sits within the international benchmark range reported by recent multinational reviews (typically 5–12 per 1,000 patient-days when measured through incident-reporting systems) [12,13], suggesting that the surface incidence in the participating hospitals is comparable to international peers. Second, errors are not concentrated at a single stage of the medication-use process: prescribing and transcription contributed 41% and administration contributed 38%, mirroring the well-documented internationally that medication safety is a multi-stage problem requiring multi-stage solutions [14]. Third, the most prevalent NCC MERP severity bands were C–D (more than half of events), with a small but non-trivial 1.9% reaching G–I categories, indicating that the harm potential is meaningful even where the modal event is non-harmful. Fourth, frontline nurses converge with the documented data in attributing the leading causes to system factors—workload, distractions, packaging, prescription legibility, and double-check protocols—rather than to individual nurse limitations.

The reporting behavior data deserve particular emphasis. International literature consistently indicates that incident-reporting systems capture only a fraction of actual events [15,16], and our finding that 52.2% of nurses had witnessed at least one unreported error in the prior six months is consistent with that pattern. The strongest predictor of having witnessed unreported errors—perception of a punitive reporting culture (aOR 2.85)—is the dimension over which hospital leadership has the most direct, low-cost control. Three institutional responses follow logically from the evidence: (i) anonymous reporting pathways with documented non-retaliation policies; (ii) structured, visible feedback to staff on the outcomes of submitted reports, which directly addresses the second-most-cited deterrent; and (iii) institutional messaging that frames medication errors as system events rather than individual failures, consistent with the broader patient-safety culture literature [17,18].

The convergence of Phase 1 and Phase 2 data within Reason's Swiss-Cheese model produces a clear, prioritized prevention roadmap. At the organizational layer, workload review and protected medication-administration time—endorsed by 68.4% of nurses—offer the most immediate operational improvement and align directly with the 38% of documented errors occurring at administration. At the layer of preconditions for unsafe acts, packaging-driven distinguishability of look-alike/sound-alike products (endorsed by 72.5%) addresses the documented 10.6% wrong-drug rate and is a low-cost intervention deliverable through hospital

pharmacy procurement decisions. At the layer of supervisory factors, structured double-check protocols for high-alert medications (78.1% endorsement) directly address the most-cited preventable cause and have demonstrated effect in international evaluations [19,20]. At the layer of unsafe acts, electronic prescribing—where feasible—addresses both prescription legibility (62.5% endorsement) and the dispensing-stage errors that constitute 12.5% of documented events [21,22]. None of these four interventions requires major capital investment beyond the electronic-prescribing component, and all four are deliverable within existing hospital-governance structures.

Two analytic features warrant brief discussion. First, the mixed-methods approach materially strengthens the inferential basis: had we relied on incident-report data alone, we would have under-estimated the true error rate by a factor that the 52.2% witnessing-unreported figure suggests is at least 1.5–2×; had we relied on the survey alone, we would have lacked the severity distribution and stage classification that make the prevention roadmap concrete. Second, the use of NCC MERP, the GRAMMS framework, and Reason's Swiss-Cheese model is intentional: each is the gold standard in its respective component (severity classification, mixed-methods reporting, error-causation theory), and their joint use is what permits integration of the two phases into a single prioritized intervention plan.

Limitations should be acknowledged candidly. First, Phase 1 relies on incident-report data, which the Phase 2 results themselves indicate are subject to substantial under-reporting; the documented 8.4-per-1,000-patient-days rate should therefore be treated as a lower bound rather than a true incidence estimate. Second, the cross-sectional design of Phase 2 cannot establish causation between perceived reporting culture and witnessing of unreported errors. Third, the participating hospitals are large urban government teaching institutions; smaller and rural facilities may show different patterns, and the documented severity distribution may be conservative because of differential reporting of less severe events. Fourth, the survey instrument was investigator-developed (drawing on the Medication Administration Error Reporting Survey [11]) and, while showing acceptable internal consistency, has not been externally validated in Iraqi nursing populations. Fifth, the integration framework was Reason's Swiss-Cheese model rather than the more recent Human Factors and Ergonomics in Healthcare framework [23], which may limit comparability with newer published prevention frameworks. Sixth, no patient-outcome or cost data were collected; whether implementation of the proposed prevention roadmap reduces patient harm and at what cost is the natural next research question.

5. CONCLUSIONS

Across three Iraqi teaching hospitals, the documented medication-error rate of 8.4 per 1,000 patient-days sits within the international benchmark range, but more than half of surveyed nurses had witnessed unreported events in the prior six months, indicating substantial under-reporting. Errors were distributed across the medication-use process, with prescribing/transcription and administration jointly accounting for nearly 80% of documented events; 11.7% of events caused at least temporary harm, and 1.9% caused permanent harm or worse. Frontline nurses converge with the documented data in attributing causation primarily to system factors—workload, distractions, look-alike packaging, illegible prescriptions, and absent double-check protocols. A prioritized hospital-level prevention roadmap, anchored to Reason's Swiss-Cheese framework, should sequence: (i) non-punitive incident-reporting culture with visible feedback to staff; (ii) structured double-check protocols for high-alert medications; (iii) packaging-driven distinguishability of look-alike products; and (iv) protected medication-administration time. Longitudinal evaluation should track whether implementation reduces both documented and underlying error rates and improves measurable patient outcomes.

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