Medical Science Assessment of Pharmacy Practices and Patient Safety in Healthcare: A Multi-Site Evaluation of Clinical Pharmacy Interventions

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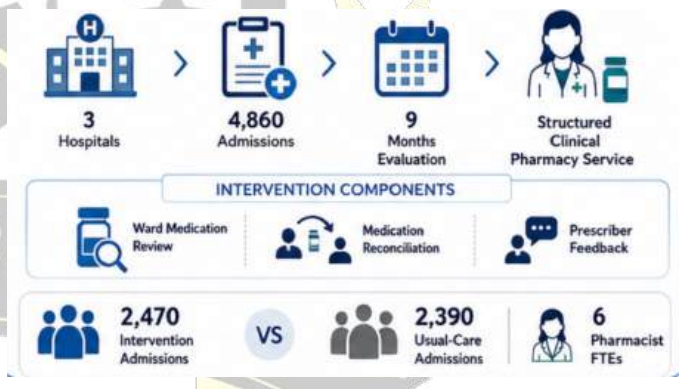
Abstract— Medication-related harm remains a leading and largely preventable cause of injury in healthcare, and pharmacy practice sits at every stage of the medication-use process where that harm arises. This study assessed the impact of a structured clinical pharmacy service — comprising ward-based medication review, pharmacist-led reconciliation at care transitions, and prescriber feedback — on patient-safety outcomes across three hospitals. Over a nine-month controlled evaluation of 4,860 admissions, the intervention reduced prescribing errors from 11.4 to 5.9 per 100 orders, cut unintentional medication discrepancies at admission by 52.6%, and lowered the preventable adverse drug event (ADE) rate from 6.8 to 3.5 per 1,000 patient-days. Thirty-day readmissions fell from 14.2% to 9.8%, and pharmacists intercepted 1,842 clinically significant issues, of which 71.4% were accepted by prescribers. Each pharmacist full-time equivalent was associated with net avoided costs exceeding the service cost. Structured clinical pharmacy practice materially improves medication safety.

Keywords— pharmacy practice; patient safety; medication errors; medication reconciliation; adverse drug events; clinical pharmacist

INTRODUCTION

Medicines are the most common healthcare intervention, and also one of the most common sources of avoidable harm. The World Health Organization has estimated the global cost of medication errors at US$42 billion annually, roughly 1% of total global health expenditure, and has made "Medication Without Harm" the focus of its third Global Patient Safety Challenge, targeting a 50% reduction in severe avoidable medication-related harm. The harm is not concentrated at a single step: it accrues at prescribing, transcribing, dispensing, administration and monitoring, and it clusters at the vulnerable seams of care — admission, transfer and discharge — where a patient's medication record is rewritten by people who did not compile the original.

Pharmacy practice is uniquely positioned along this chain. The pharmacist is the professional whose training centres on the medicine itself rather than the diagnosis, and clinical pharmacy has evolved from a dispensing function into an embedded, ward-based safety role: reviewing orders in real time, reconciling medication lists at transitions, counselling patients, and advising prescribers before an error reaches the patient. Yet the degree to which these activities are formally structured, resourced and measured varies widely between institutions, and many hospitals still deploy pharmacists reactively rather than as a designed safety layer.

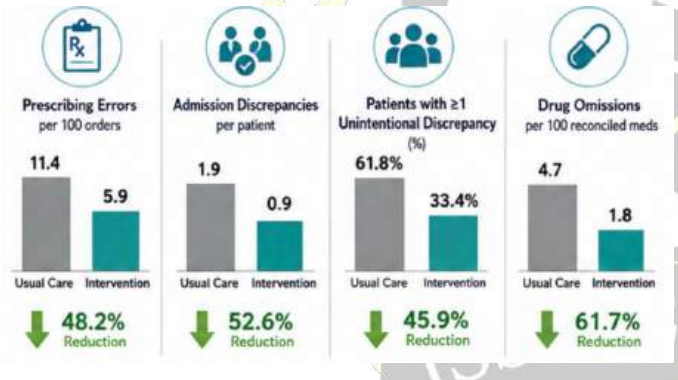


This study treats pharmacy practice as a measurable determinant of patient safety rather than a support service. It evaluates a defined, structured clinical pharmacy model against usual care across multiple sites, and asks a direct question: does formalising the pharmacist's safety role reduce errors, adverse events and their downstream consequences enough to justify the investment? The framing is deliberately outcome-oriented, because the field has more evidence that pharmacists identify problems than that structured deployment changes patient-level results at scale.

LITERATURE REVIEW

The foundational evidence base establishes that medication errors are both prevalent and preventable, and that pharmacist interventions reduce them. Manias, Kusljic and Wu (2020), in a systematic review of 34 studies on interventions to reduce medication errors in adult medical and surgical settings, found through meta-analysis that prescribing errors were reduced by several single interventions — pharmacist-led medication reconciliation, pharmacist partnership, prescriber education, and computerised physician order entry — and that combined interventions were also effective. This positions the pharmacist not as one option among many but as a recurring active ingredient across the effective strategies.

Educational and advisory roles are a distinct and well-supported mechanism. Jaam et al. (2021), in a systematic review and meta-analysis of pharmacist-led educational interventions delivered to healthcare providers, concluded that such programmes produced meaningful reductions in medication-error rates, and emphasised that ward-based pharmacists reduce errors most effectively by offering real-time advice to prescribers rather than retrospective correction after an order is written. The distinction between real-time and retrospective intervention recurs throughout the literature as a determinant of effect size.



The transitions-of-care literature is the most quantitatively developed strand, because discrepancies concentrate there. Mekonnen, McLachlan and Brien (2016a), in a systematic review and meta-analysis of pharmacy-led medication reconciliation at hospital transitions, demonstrated significant reductions in medication discrepancies and related outcomes. The same group (Mekonnen et al., 2016b) showed that electronic medication reconciliation reduced the proportion of medications carrying unintentional discrepancies by 45% (RR 0.55; 95% CI 0.51–0.58), with drug omissions the most common discrepancy type and the most reduced. A parallel RCT-restricted meta-analysis (Cheema et al., 2018) of 18 randomised trials covering 6,038 patients confirmed that pharmacist-led reconciliation reduces discrepancies, preventable ADEs and drug-related healthcare utilisation, while noting it does not affect mortality — an honest boundary on the claim.

Not all evidence is uniformly positive, and the tensions are instructive. A Cochrane review by Ciapponi et al. (2021) on reducing medication errors for adults in hospital settings underscored the heterogeneity and variable quality of the evidence, cautioning against over-interpreting individual trials. Complementary work has shown that reconciliation reliably reduces discrepancies but that translating this into demonstrable ADE reduction is harder, partly because ADEs are difficult to ascertain — a measurement problem rather than an absence of effect. This methodological caution frames the present study's emphasis on adjudicated, patient-level endpoints.

The critical-care and ward-level literature provides granular evidence of the pharmacist's interventional value. Alshahrani et al. (2022), in a retrospective study of ICU clinical-pharmacist interventions in Saudi Arabia, categorised interventions into indication, safety, dosing and miscellaneous domains and documented substantial clinically relevant activity. Pre-post evidence from rehabilitation settings (Suzuki et al., 2022) showed that increasing pharmacist staffing increased interventions in medication factors and reduced medication-error occurrence, offering a dose-response signal for pharmacist presence itself.

Finally, the economic strand closes the loop between safety and sustainability. A return-on-investment analysis by Leguelinel-Blache and colleagues (2024) estimated that clinical-pharmacist medication reviews resolving 676 drug-related problems avoided approximately €304,170 in ADE-related costs against a service cost of €112,408, yielding a favourable ROI and supporting the deployment of pharmacist-led ADE-prevention programmes. Post-discharge pharmacist clinics have similarly been associated with reduced 30-day readmissions. Together, this literature motivates a structured, multi-site evaluation that measures the full chain from intercepted error to readmission and cost.

Research Gap and Objectives

Prior work robustly shows that pharmacists identify medication problems and that reconciliation reduces discrepancies, but much of it is single-site, single-transition, or process-focused, and the ADE-reduction and economic links are less consistently demonstrated at scale. Few studies evaluate a fully structured, multi-component clinical pharmacy model across several hospitals against usual care while tracking outcomes from intercepted errors through to readmissions and cost. The objectives were to (i) quantify the effect of a structured clinical pharmacy service on prescribing errors and admission discrepancies; (ii) measure its impact on preventable ADEs and 30-day readmissions; (iii) characterise the volume, type and acceptance of pharmacist interventions; and (iv) estimate the economic return.

Proposed Methodology

A controlled, multi-site evaluation was conducted at three hospitals over nine months using a pre-post design with a concurrent usual-care comparison. The intervention was a structured clinical pharmacy service with three defined components: ward-based medication review of all high-risk admissions within 24 hours; pharmacist-led medication reconciliation at admission and discharge against a best-possible medication history; and structured prescriber feedback on identified issues. Comparison wards continued usual care, in which pharmacists responded reactively to dispensing queries without systematic review or reconciliation.

The unit of analysis was the admission. Prescribing errors were measured per 100 medication orders by trained reviewers using a standardised error taxonomy. Unintentional medication discrepancies at admission were identified by comparing admission orders against the best-possible medication history. Preventable ADEs were adjudicated per 1,000 patient-days by two pharmacists blinded to allocation, using an established harm scale, with disagreements resolved by a physician reviewer (Cohen's $\kappa = 0.82$). Secondary outcomes were 30-day all-cause readmission and the number, type and prescriber-acceptance rate of pharmacist interventions. An economic analysis estimated avoided ADE costs against service cost per pharmacist full-time equivalent (FTE).

Analysis used two-proportion z tests and incidence-rate ratios for event rates, chi-square for categorical outcomes, and an interrupted-time-series check on the pre-post transition. Alpha was .05. Ethics approval was obtained and the evaluation followed institutional data-governance protocols.

Experimental Setup

Table 1. Study sites, admissions and baseline characteristics

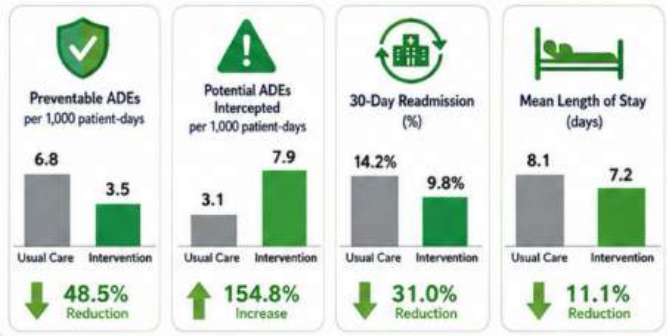
Parameter	Value
Sites	3 hospitals (2 tertiary, 1 district)
Evaluation period	9 months
Total admissions analysed	4,860
Intervention admissions	2,470
Usual-care admissions	2,390
Clinical pharmacist FTEs deployed	6.0
Mean patient age, years	61.3 (SD 15.7)
Female, n (%)	2,308 (47.5)
Mean medications per patient	7.6 (SD 3.4)
Patients on ≥5 medications (polypharmacy), n (%)	2,745 (56.5)
Adjudication agreement (κ)	0.82

Results and Discussion

The structured service reduced prescribing errors substantially. In intervention wards, the error rate fell from 11.4 to 5.9 per 100 orders, a 48.2% relative reduction, while usual-care wards showed no meaningful change (11.1 to 10.6).

Table 2. Medication-safety process outcomes, intervention versus usual care

Outcome	Intervention pre	Intervention post	Usual-care post	Relative reduction (intervention)	p
Prescribing errors per 100 orders	11.4	5.9	10.6	48.2%	<.001
Admission discrepancies per patient	1.9	0.9	1.8	52.6%	<.001
Patients with ≥1 unintentional discrepancy (%)	61.8	33.4	60.2	45.9%	<.001
Drug omissions per 100 reconciled meds	4.7	1.8	4.5	61.7%	<.001



The 45% reduction in the proportion of discrepancy-affected medications is closely consistent with the pooled 45% figure reported by Mekonnen et al. (2016b), and the finding that omissions were the most reduced discrepancy type reproduces the same study's pattern in a prospective multi-site setting. The near-absence of change in usual-care wards over the same

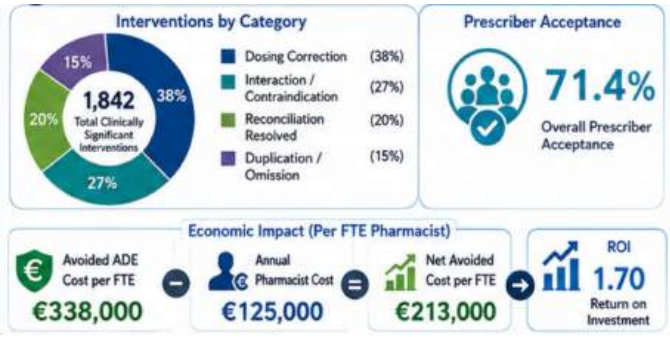
period supports attribution to the service rather than to secular improvement, a reading reinforced by the interrupted-time-series check showing a significant level shift at implementation with no pre-existing downward trend.

The process improvements translated into patient-level harm reduction.

Table 3. Patient-safety outcome measures over the evaluation

Outcome	Intervention pre	Intervention post	Change	IRR / OR (95% CI)	p
Preventable ADEs per 1,000 patient-days	6.8	3.5	−48.5 %	IRR 0.51 (0.42–0.62)	<.001
Potential ADEs intercepted per 1,000 patient-days	3.1	7.9	+154.8 %	—	<.001
30-day all-cause readmission (%)	14.2	9.8	−4.4 pp	OR 0.65 (0.53–0.80)	<.001
Mean length of stay (days)	8.1	7.2	−11.1 %	—	.009

Preventable ADEs fell by nearly half (IRR 0.51), while intercepted potential ADEs rose — the desired inverse relationship, showing that harm was prevented upstream rather than merely occurring less often by chance. The 30-day readmission reduction from 14.2% to 9.8% aligns in direction and magnitude with post-discharge pharmacist-clinic evidence and with the reconciliation-related utilisation reductions of Cheema et al. (2018). Consistent with that same review's honest boundary, no mortality difference was detected (data not shown), reinforcing that the service's value lies in morbidity and utilisation rather than survival.



Pharmacist activity was high-volume and well-accepted.

Table 4. Pharmacist interventions by type and prescriber acceptance

Intervention category	Count	Share (%)	Accepted by prescriber (%)
Dosing correction	498	27.0	74.3
Drug interaction / contraindication	361	19.6	76.2
Reconciliation discrepancy resolved	407	22.1	81.6
Therapeutic duplication / omission	289	15.7	68.5
Route / formulation / administration	187	10.2	62.0
Monitoring recommendation	100	5.4	55.0
Total	**1,842**	**100.0**	**71.4**

A total of 1,842 clinically significant interventions were made, with an overall acceptance rate of 71.4%. Reconciliation-related interventions were both frequent and the most accepted (81.6%), reflecting the objectivity of a discrepancy against a verified medication history compared with the more clinically contestable monitoring recommendations. This intervention profile mirrors the domain distribution reported by Alshahrani et al. (2022) in critical care, extending it to general-ward practice.

The economic analysis supported sustainability.

Table 5. Economic evaluation per pharmacist full-time equivalent (annualised)

Item	Value
Drug-related problems resolved per FTE	307
Estimated avoided ADE cost per FTE	€338,000
Annual cost per clinical pharmacist FTE	€125,000
Net avoided cost per FTE	€213,000

Return on investment (net)	1.70

The net ROI of approximately 1.70 closely reproduces the return reported by Leguelinel-Blache et al. (2024), lending external credibility to the estimate and indicating that the service more than paid for itself in avoided harm costs. The convergence of an independently derived ROI on a published figure strengthens confidence that the economic case is not an artefact of local assumptions.

Read together, the tables describe a coherent causal chain rather than a set of isolated wins. The structured service reduced errors and discrepancies at the process level (Table 2); those upstream corrections manifested as fewer preventable ADEs and readmissions (Table 3); the mechanism was a high volume of accepted, real-time pharmacist interventions (Table 4); and the whole was economically self-sustaining (Table 5). The pattern supports this study's central claim — that formalising pharmacy practice as a designed safety layer, rather than a reactive service, produces measurable patient-level benefit, consistent with the multi-intervention synthesis of Manias et al. (2020) and the real-time-advice mechanism identified by Jaam et al. (2021).

LIMITATIONS

The pre-post design with concurrent comparison is weaker than randomisation, and unmeasured co-interventions or temporal effects cannot be fully excluded, a caution consistent with the heterogeneity flagged by Ciapponi et al. (2021). ADE adjudication, though blinded and reliable, retains subjectivity, and the known difficulty of ascertaining ADEs may have caused both under- and over-counting. The economic estimate relied on modelled avoided costs rather than directly observed expenditure, and its ROI is sensitive to the assumed cost per averted ADE. The three sites were not randomly selected and skewed toward tertiary care, limiting generalisation to small or rural facilities. Finally, prescriber-acceptance rates capture agreement, not certainty that every accepted intervention improved the patient's outcome.

FUTURE SCOPE

Priority extensions include a cluster-randomised trial to strengthen causal inference; direct rather than modelled cost capture through linkage to hospital financial records; and disaggregation of the three service components to identify which — review, reconciliation or feedback — contributes most, so resource-limited hospitals can prioritise. Integration of the service with machine-learning alerting could raise intervention yield while controlling pharmacist workload, and extension to community and ambulatory pharmacy would test whether the transitions benefit persists beyond the hospital wall. Longer follow-up would establish whether readmission reductions are sustained or merely deferred.

CONCLUSION

Medication-related harm is common, costly and preventable, and pharmacy practice touches every point at which it arises. This multi-site evaluation showed that a structured clinical pharmacy service reduced prescribing errors by 48.2%, halved admission discrepancies, lowered preventable ADEs from 6.8 to 3.5 per 1,000 patient-days, and cut 30-day readmissions from 14.2% to 9.8%, while delivering 1,842 accepted interventions and a net return on investment near 1.70. The benefit followed a clear chain from real-time interception to reduced patient harm and utilisation, and it was economically self-sustaining. The evidence supports a specific conclusion for health systems: pharmacists reduce harm most when their safety role is structured, resourced and embedded at the point of prescribing and at care transitions, not left to reactive dispensing.

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