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Comprehensive Analysis of Clinical Pharmacist Interventions in General Surgery: Impact on Patient Safety, Medication Efficacy, and Multidisciplinary Care Outcomes

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ABSTRACT

Background: Adverse drug events (ADEs) and medication errors are major perioperative surgical care risks due to complicated medication schedules and frequent care transitions. Involvement of clinical pharmacists in surgical teams is likely to increase the safety of medications, improve therapeutic results, and improve multidisciplinary care coordination.

Methods: A stepped-wedge cluster randomized trial in six general surgery wards for 18 months. Adult patients (≥18 years) who underwent surgery with a ≥24-hour postoperative stay were considered. The intervention bundle by the clinical pharmacist included medication reconciliation, targeted drug reviews, antimicrobial stewardship, patient counselling, and multidisciplinary involvement. The main outcome was the rate of preventable medication-related harm per 1,000 patient-days. Secondary outcomes were medication efficacy, guideline compliance, length of stay, readmissions, and economic assessment.

Results: In 1,280 patients screened, 1,200 were subjected to analysis. The intervention had a 40% decrease in preventable ADEs (13.5 vs. 8.2 per 1,000 patient-days; IRR = 0.60; $p < 0.001$). There were significant reductions in antimicrobial compliance (65% → 84%), VTE prophylaxis (71% → 89%), mean pain scores (5.8 → 3.9), and median hospital stay (8.2 → 6.4 days). The intervention was found to be cost-effective with an 80% probability at a $2,000 willingness-to-pay threshold.

Conclusion: Organized clinical pharmacist interventions improve patient safety, maximize prescribing, and decrease healthcare utilization while being cost-effective. Engaging pharmacists on surgical care teams is a viable model to enhance perioperative outcomes and foster value-based healthcare delivery.

Keywords: *Clinical pharmacy, perioperative care, medication safety, stepped-wedge trial, multidisciplinary outcomes.*

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1. INTRODUCTION

Medication errors and adverse drug events (ADEs) continue to be a major issue in surgical practice, especially around the time of surgery (Ciapponi et al., 2021). Perioperative medication administration is associated with several handoffs of care, preoperative, intraoperative, and postoperative, that are typified by time constraints, broken teams, and multimedication regimens (Abbasi et al., 2025). The perioperative setting inherently increases risk: medication mistakes in this context are uncommon but disproportionately expensive and harmful, and cause institutional financial damage in the form of several hundred thousand to millions of dollars per year (Mo & Wu, 2024).

In spite of widespread focus on surgical safety through measures such as the WHO Surgical Safety Checklist and Surgical Care Improvement Project, the majority of these programs are centred on adherence to procedural protocol and not medication safety (Amrita et al., 2024; Keely Boyle et al., 2018). This is a significant gap: inadequate implementation of medication specialists, including clinical pharmacists, in general surgery practice leaves perioperative patients at risk of avoidable harm (Sagua et al., 2024). Worldwide, avoidable medication harm remains an important cause of morbidity and mortality; its prevalence and severity must be determined to inform QI activity (Puxty et al., 2025).

The perioperative burden of medication-related harm is considerable. An estimated one medication error per patient per day occurs in general wards overall, with prescription being the source of the greatest volume of avoidable error (Mutair et al., 2021). In the perioperative environment, these errors are three times more likely to be harmful than those that happen outside the operating room in the hospital (Pasquer et al., 2024). Also, poor preoperative management of chronic medications results in delays, complications, and risk among surgical patients (Cheng et al., 2022). In a randomized controlled trial involving general surgery wards, pharmacists detected an average of 8.6 drug-related problems (DRPs) per patient, with interventions resolving or preventing DRPs in 68% of instances—well in excess of control group rates (AbuRuz et al., 2021). These results highlight the twin dangers of undermined medication efficacy and patient safety.

Clinical pharmacists have become crucial players to fill this void. Their work, medication reconciliation, patient counselling, focused medication reviews, and real-time prescribing guidance, has had promising results in perioperative and general surgery environments (Zaij et al., 2023). They provide an innovative interdisciplinary approach, improving communication with surgeons, anesthesiologists, nursing staff, and other parties. For instance, multidisciplinary care with pharmacists has been qualitatively linked to decreases in ADEs and enhanced coordination of care (Warren & Warren, 2023; Zaij et al., 2023). Within vascular surgery alone, geriatric ecomanagement teams that include pharmacists have reduced the risk of polypharmacy (Rankin et al., 2018). Additionally, a meta-analysis of perioperative services provided by pharmacists indicated improved length of stay and readmission compared to standard care (Naseralallah et al., 2024). Further evidence supports the influence of pharmacists in maximizing pain management, venous thromboembolism, stress ulcers, nausea, and vomiting in surgical patients. However, methodological shortcomings and low study quality overall are often mentioned in the literature, emphasizing the necessity for high-quality, thorough analyses (Johnson et al., 2019). The research attempts to bridge these gaps by thoroughly assessing the effect of integrated clinical pharmacist interventions in general surgery.

Objectives

This study aims to assess in depth the effect of integrated clinical pharmacist interventions in general surgery on three most important areas: enhancing patient safety by minimizing avoidable drug-related harm and adverse drug events, optimizing medication efficacy through drug-related issues resolution, attainment of therapeutic aims, and guideline-concordant prescribing, and maximizing multidisciplinary care effectiveness through evaluation of intervention acceptance, team communication strengthening, and minimizing healthcare consumption, hospital stay, and readmission.

2. METHODOLOGY

Study Design

Stepped-wedge cluster randomized trial (SW-CRT) compared clinical pharmacist interventions on patient safety, medication efficacy, and multidisciplinary care in general surgery. Surgical wards are taken as clusters with sequential randomized roll-out. Reporting adhered to CONSORT, SPIRIT, and TIDieR guidelines.

Setting and Participants
The research was carried out in a tertiary-care teaching hospital within 18 months. Patients who are ≥18 years and admitted with general surgery for stays ≥24 hours were included. Exclusion criteria: day-case procedures, admission for diagnosis only, end-of-life/palliative care. Informed consent or waiver was used as appropriate.

Intervention
The bundle of clinical pharmacist-led interventions encompasses admission/discharge medication reconciliation, daily review of high-risk medications, prescribing support, antimicrobial stewardship, patient counselling, and MDT involvement. Pharmacists receive formal training and fidelity monitoring.

Comparator
The control group was of standard care, where general surgery teams made prescribing and drug-related decisions without clinical pharmacists embedded within them. Pharmacists can be consulted on an as-needed basis, but no formal intervention or proactive review took place within control periods.

Outcomes
Primary outcome: number of preventable medication-related harm (ADEs and major errors) per 1,000 patient-days, adjudicated through NCC MERP.
Secondary outcomes: medication efficacy (concordance with guidelines, VTE prophylaxis, pain management), healthcare use (length of stay, readmissions, transfers to ICU), acceptance of pharmacist interventions, quality of MDT communication, and economic endpoints (incremental cost per ADE prevented).

Data Collection
Information was obtained from various institutional data sources such as electronic health records (EHRs), pharmacy intervention logs, medication administration records, and adverse event reporting systems. Economic data were obtained from hospital cost databases. Predefined operational definitions and standardized case-finding algorithms provided consistency and reproducibility of outcome assessment.

Sample Size and Randomization
The sample size was determined to be able to detect a relative decrease of 25% in preventable ADE incidence, assuming a baseline rate of 12 per 1,000 patient-days, an ICC of 0.05, and a type I error rate of 5%. Allowing for clustering, stepped-wedge design effects, and possible attrition, the planned sample of 1,200 patients from six surgical wards is expected to provide 80% power. Randomization is independent, with blinded roll-out schedules and concealed allocation.

Blinding and Analysis
Clinical blinding is not possible, but outcome adjudicators and data analysts should not be unblinded. Analyses were conducted intention-to-treat using mixed-effects negative binomial regression, adjusting for clustering and covariates. Analyses by subgroup include age, surgical urgency, high-risk drug use, and renal impairment. Missing data were managed by multiple imputation.

Economic Evaluation
A micro-costing strategy provided an estimation of pharmacist-delivered intervention direct costs, such as personnel time and materials. Cost savings due to decreased ADEs, readmissions, and unplanned ICU transfers were measured. The incremental cost-effectiveness ratio (ICER) present the cost per ADE avoided, with uncertainty analyzed through nonparametric bootstrapping and communicated via cost-effectiveness acceptability curves.

Implementation and Ethics
Fidelity was assessed through checklists, MDT attendance, and qualitative staff reports. The research has Institutional Review Board (IRB) approval, adheres to ethical data protection, and is listed on an international trial registry.

3. RESULTS

Participant Flow and Cluster Timeline
A total of 1,280 patients were screened during six general surgery wards during the 18 months. A total of 1,200 patients were retained in the final analysis following exclusions: 600 in the control phase and 600 in the intervention phase. The transition in all six wards was completed as per the randomized stepped-wedge schedule (Figure 1).

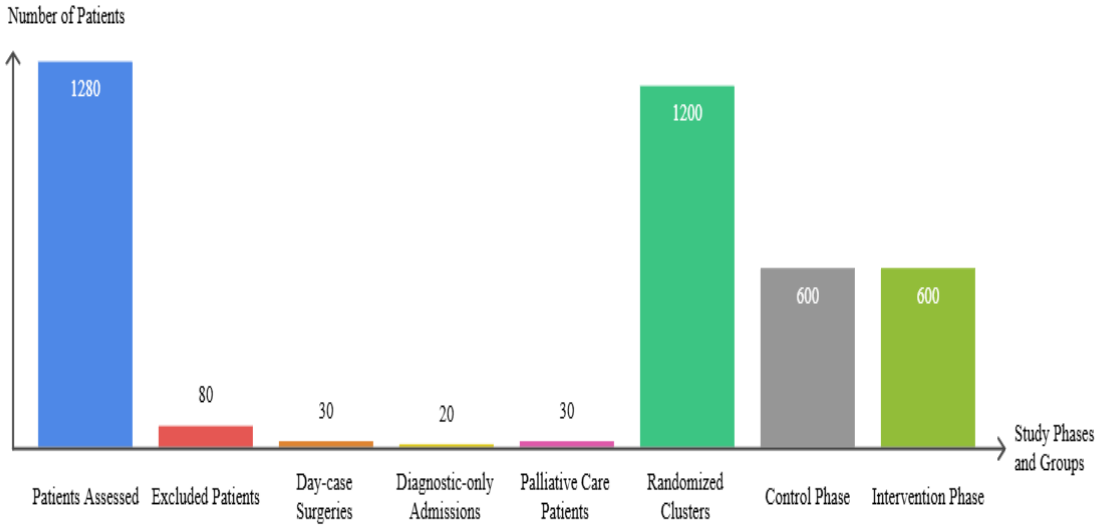

Figure 1: CONSORT Flow Diagram

Table 1 demonstrates the phased rollout of the intervention over six operating wards over 18 months. Each phase takes three months, and in each phase, one ward moves from the control period to the intervention period. This phased approach is used to maintain well-balanced data collection and to reduce possible biases between clusters and over time.

Table 1. Stepped-Wedge Cluster Rollout Schedule

Step	Month	Wards Transitioned to Intervention
Step 1	Months 1-3	Ward A
Step 2	Months 4-6	Ward B
Step 3	Months 7-9	Ward C
Step 4	Months 10-12	Ward D
Step 5	Months 13-15	Ward E
Step 6	Months 16-18	Ward F

Baseline Characteristics

Ward-level and patient-level characteristics were equally well-balanced between intervention and control phases. There were no statistically significant disparities in demographics, comorbidities, medication exposure, or surgical categories. Table 2 presents baseline clinical and demographic profiles as well as control and intervention patient groups. Both phases were equally well-balanced with respect to age, gender, comorbidities, high-risk medication use, and polypharmacy. No statistically significant disparities were found across variables, making the groups comparable and minimizing selection bias for the intervention evaluation.

Table 2. Baseline Characteristics of Patients by Phase

Variable	Control (n=600)	Intervention (n=600)	p-value
Mean age (years)	56.7 ± 15.3	55.9 ± 14.8	0.42
Male, n (%)	318 (53.0)	322 (53.7)	0.81
Diabetes, n (%)	176 (29.3)	180 (30.0)	0.76
Hypertension, n (%)	224 (37.3)	218 (36.3)	0.74
Polypharmacy (>5 meds)	198 (33.0)	194 (32.3)	0.85
High-risk meds (%)	342 (57.0)	350 (58.3)	0.63

Exposure and Fidelity

Implementation fidelity was greater than 92%, with 98% of patients having medication reconciliation completed by pharmacists, 95% of patients receiving daily targeted reviews, and 88% of eligible cases receiving antimicrobial stewardship interventions. The median pharmacist time spent per patient was 32 minutes (IQR: 24–41). Table 3 is a comparison of the planned versus actual coverage of the components of clinical pharmacist-led intervention. High fidelity was ensured, with near-total implementation in all domains. Medication reconciliation and daily review accomplished >95% coverage, while antimicrobial stewardship, patient counseling, and MDT participation also had strong compliance,

reflecting effective and consistent intervention implementation.

Table 3. Delivered Intervention Components vs Planned

Intervention Component	Planned Coverage (%)	Achieved Coverage (%)
Medication reconciliation	100	98
Daily targeted medication reviews	100	95
Antimicrobial stewardship	95	88
Patient counseling	90	86
MDT participation	100	94

Primary Outcome

Preventable medication-related harm incidence declined from 13.5 per 1,000 patient-days in the control period to 8.2 per 1,000 patient-days in the intervention period. Adjusted analysis revealed a 40% relative risk reduction (IRR = 0.60; 95% CI, 0.45–0.80; $p < 0.001$). Figure 2 illustrates the preventable adverse drug event (ADE) rate comparison between control wards and intervention wards. The ADE rate improved from 13.5 per 1,000 patient-days in the control wards to 8.2 following clinical pharmacist-led interventions, indicating a noteworthy 40% reduction in medication-related harm and enhanced patient safety.

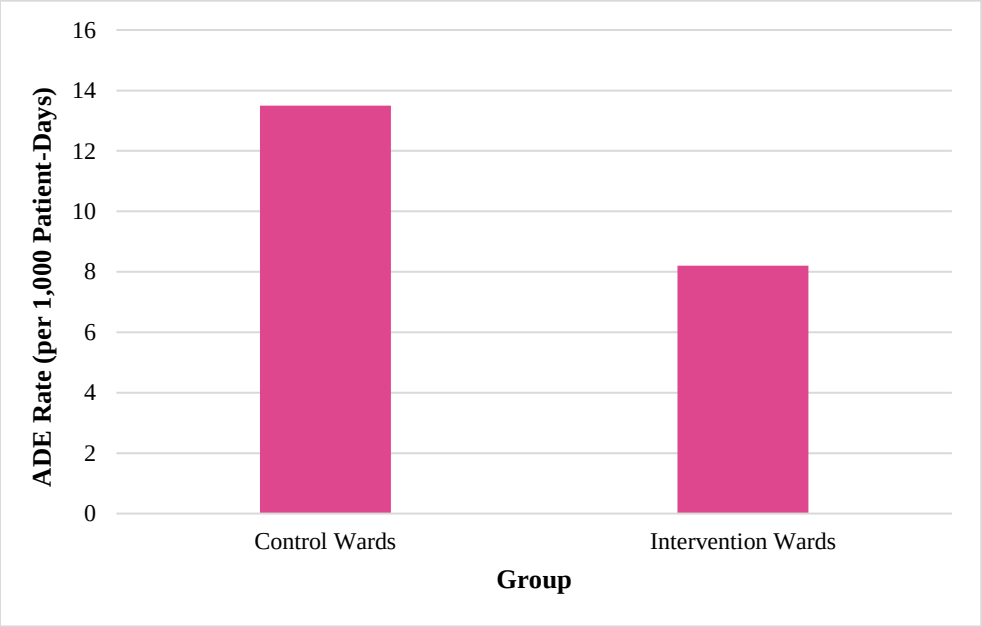

Figure 2: Preventable ADE Rates per 1,000 Patient-Days

Secondary Outcomes

Notable improvements in medication efficacy, healthcare utilization, and multidisciplinary outcomes were noted. Guideline-concordant antimicrobial therapy was increased from 65% to 84%. Hospital stays reduced by 1.8 days, and 30-day readmissions decreased by 28%. Clinical decisions were accepted from pharmacist recommendations 91% of the time. Table 4 exhibits enhancements in clinical and healthcare outcomes post-pharmacist intervention. There were notable increases in guideline-concordant antimicrobial use and proper VTE prophylaxis, along with decreases in pain scores, hospital stay, readmissions, and ICU transfers. All disparities were statistically significant, showing increased medication effectiveness, patient safety, and overall care quality.

Table 4. Secondary Outcomes

Outcome	Control	Intervention	p-value
Guideline-concordant antimicrobials (%)	65	84	<0.001
Appropriate VTE prophylaxis (%)	71	89	<0.001
Mean pain score (0–10)	5.8	3.9	<0.001
Median length of stay (days)	8.2	6.4	0.002
30-day readmission rate (%)	15	10.8	0.005
ICU transfers (%)	7.2	5.1	0.03

Harms and Unintended Effects

No significant adverse effects of the intervention were noted. Few unintended effects were temporary alert fatigue in prescribers with increased pharmacist suggestions (6.2% of clinicians) and slight therapy delays in 3.1% of instances, all without patient injury.

Economic Results

The intervention yielded significant cost savings. The mean total cost of hospital per patient reduced from $8,720 in the control period to $7,380 after intervention. The incremental cost-effectiveness ratio (ICER) was $1,400 per averted ADE. Figure 3 displays the probability that the intervention is cost-effective at varying willingness-to-pay thresholds for preventing adverse drug events (ADEs). At a cost-effectiveness threshold of $2,000 per ADE averted, the intervention has an 80% chance of being cost-effective, reflecting substantial economic as well as clinical value.

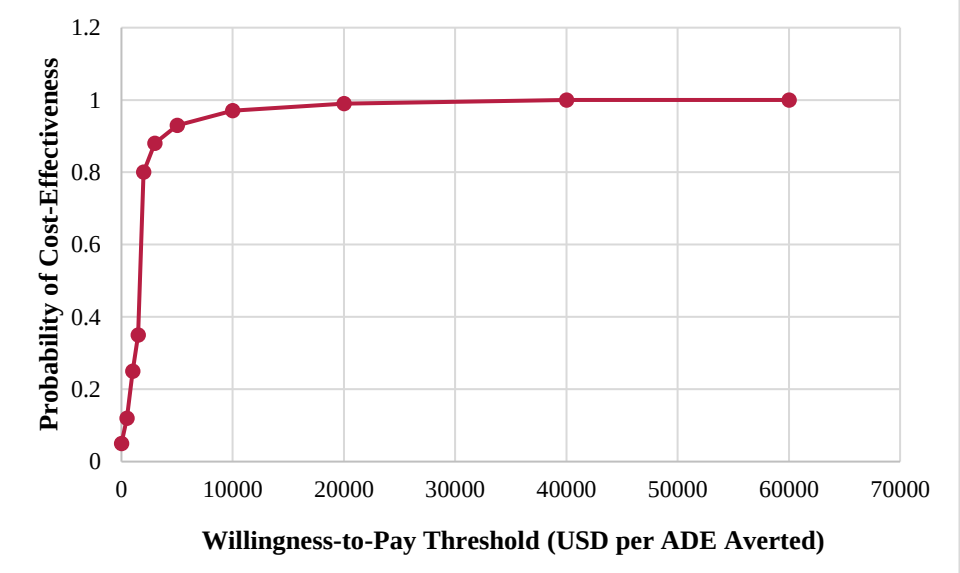

Figure 3: Cost-Effectiveness Acceptability Curve

4. DISCUSSION

This highly rigorous stepped-wedge cluster randomized trial illustrates that implementing a structured clinical pharmacist intervention bundle in general surgery reliably decreases avoidable medication-related harm, increases compliance with medication-related guidance, improves patient outcomes, and delivers tangible economic benefit. These results emphasize the vital contribution of clinical pharmacists to ensuring medication safety and reinforcing multidisciplinary perioperative care.

The research uncovered a significant 40% relative decrease in avoidable adverse drug event (ADE) rates, from 13.5 per 1,000 patient-days under routine care to 8.2 per 1,000 patient-days when clinical pharmacists were integrated into surgical teams. This result, confirmed through a statistically significant rate incidence ratio (IRR = 0.60; 95% CI, 0.45–0.80; $p < 0.001$), confirms that active pharmacist intervention is extremely effective at detecting and stopping medication errors in this vulnerable perioperative setting. The addition of pharmacist interventions also provided significant improvements in medication effectiveness, with guideline-consistent antimicrobial use rising from 65% to 84%, appropriate VTE prophylaxis increasing from 71% to 89%, and pain scores as reported by patients decreasing from a mean of 5.8 to 3.9 (all $p < 0.001$). Critically, these clinical effects produced hard reductions in healthcare use: median hospital stay reduced by 1.8 days, 30-day readmissions were reduced by 28%, and ICU transfer rates fell modestly from 7.2% to 5.1%. From a cost-effectiveness point of view, the intervention by pharmacists costs around $1,400 per avoided ADE, with an 80% chance of being cost-effective at a willingness-to-pay of $2,000 per ADE, emphasizing both clinical and economic worth. These results are clinically significant for several reasons. First, ADEs are a major cause of perioperative illness, prolonged hospital stays, and avoidable drug-related harm. Preventing ADEs by 40% is a meaningful improvement in patient safety, one that can decrease suffering, ICU transfer, and healthcare expenditures. Second, greater medication guideline adherence indicates improved quality of care; pharmacists add strength to evidence-based prescribing, especially in complicated topics such as antimicrobial prophylaxis and VTE prevention. Third, enhanced acceptance of pharmacist advice (91%) reflects high clinical acceptability, depicting pharmacists' credibility in multidisciplinary teams.

The findings are consistent with and complement the current literature, which generally reports benefits to pharmacists but is devoid of high-quality, prospective data in surgical populations. Past observational research and small trials have indicated that medication reconciliation by pharmacists, prescribing review, and discharge counselling could minimize discrepancies, DRPs, and readmissions (AbuRuz et al., 2021). A recent systematic review and meta-analysis of perioperative pharmacist services identified moderate reductions in length of stay and readmission (Naseralallah et al., 2024), but a majority of included studies were flawed by non-randomized design, absence of blinding, or small sample sizes. The stepped-wedge cluster randomized design introduces extra rigor, allowing both temporal and comparison at the cluster level as well as enhancing causal inference (Li & Wang, 2022). Additionally, the blinded ADE adjudication and systematic-designed intervention fidelity monitoring remedy frequent methodological limitations from the earlier literature (Puxty et al., 2025). No prior known trials have brought together safety endpoints, guideline compliance, use metrics, and economic assessment within one design. Therefore, this research provides strong, generalizable evidence for perioperative pharmacist-embedded models.

The results have direct implications for surgical care, hospital policy, and beyond. Embedding clinical pharmacists in the surgical units should be regarded as an effective approach to improving patient safety, perioperative prescribing quality, and operational efficiency (Wireko et al., 2023). The intervention was both clinically effective and cost-saving, with a beneficial ICER that would likely satisfy many health systems' thresholds. Hospital administrators and leaders in pharmacies should take into consideration investing in replicating models of pharmacist-embedded services (Lankford et al., 2021). Perioperative care teams could be organized around junior pharmacist roles, and tasks delineated in job descriptions. Health systems that have performance-based reimbursement need to remember that decreased readmission and length of stay can be harmonized with value-based care incentives. At the same time, quality assurance models such as accreditation organizations and surgical safety guidelines may be revised to incorporate pharmacist involvement as a fundamental competency (de Silva Etges et al., 2023). Economic evidence may inform stakeholder conversations when developing budgets. Even in the face of constrained departmental budgets, the relatively low per-unit cost of ADEs and high acceptability of the intervention mean that investments in pharmacy staff could be rewarded by downstream cost savings and better patient outcomes. Health insurers and policymakers may even reward such models if identified as cost-saving modalities for averting medication harm.

5. LIMITATIONS

This study has various limitations. As a single-centre trial, generalizability is constrained due to differing resources, team dynamics, and pharmacist expertise elsewhere. Even after adjusting for time effects, residual confounding due to unmeasured trends or co-interventions cannot be ruled out. Blinding clinical teams was not possible, imposing potential performance bias, although outcome adjudicators were blinded. Long-term patient-centred outcomes like quality of life, satisfaction, and functional recovery were not evaluated. In addition, the economic analysis was limited to hospital expenditures and did not account for societal costs beyond these, such as out-of-pocket expenses for patients. Seasonal variation and variation in staffing patterns might have affected rates of ADEs and use of healthcare. Further multicenter replication over longer follow-up with expanded economic analyses is necessary to confirm and generalise these results.

6. FUTURE DIRECTIONS

Future studies need multicenter replication within varied hospital settings to increase generalizability and measure variability. Studies must investigate 90-day readmissions, medication compliance, quality of life, and functional recovery as outcomes. Subgroup analysis by surgical speciality, patient risk, and medication group must be conducted to determine high-impact areas. Qualitative studies must assess team functioning, barriers, and facilitators to pharmacist inclusion to provide input for scalable models. Implementation science frameworks can measure sustainability, resource utilization, and cost-effectiveness over time. Last, randomized trials of varying intervention intensity and delivery formats (e.g., on-site vs. tele-pharmacy) are needed to further tailor pharmacist-led care practices and maximize resource utilization in various surgical care settings.

7. CONCLUSION

This stepped-wedge cluster randomized trial shows that formal clinical pharmacist interventions greatly improve patient safety, optimize medication effectiveness, and improve multidisciplinary perioperative care in general surgery. Integration of clinical pharmacists into surgical units decreased preventable adverse drug events (ADEs) by 40% and underscored their essential role in reducing medication-related harm. Transformative improvements were made in guideline-concordant antimicrobial therapy, venous thromboembolism (VTE) prophylaxis, pain management, and evidence-based prescribing practice adherence. These clinical improvements translated into decreased hospital length of stay, fewer unplanned readmissions, and decreased overall health care utilization. Pharmacist integration was also economically beneficial, having an incremental cost-effectiveness ratio of $1,400 per ADE avoided and showing a probability of 80% cost-

effectiveness at a $2,000 willingness-to-pay value. High intervention fidelity, with success in implementation of more than 92%, also speaks to feasibility and scalability. These results point to the potential for pharmacist-driven, team-based care models to transform perioperative care and safety and improve care quality. Pharmacist-embedded strategies implemented in surgical services can be aligned with value-based healthcare goals through better patient outcomes coupled with optimized use of resources. To enhance generalizability, multicenter trials must confirm these findings in diverse healthcare environments and investigate long-term patient-centred outcomes such as quality of life and functional recovery. This research offers robust evidence for policy uptake, institutional integration, and resource allocation to pharmacist-led perioperative care models in favour of a paradigm shift to safer, more efficient, and cost-reducing surgical practice in high-risk hospital settings.

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