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PHARMACIST-LED MEDICATION REVIEW AND PRIORITIZATION IN HIGH-RISK HOSPITALIZED PATIENTS: A CONTEMPORARY REVIEW OF CLINICAL INTERVENTIONS AND ECONOMIC OUTCOMES

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ABSTRACT

Background: Medication-related problems represent a significant source of preventable harm in hospitalized patients, particularly among older adults and those with multiple chronic conditions. Given constrained pharmacy workforce capacity, targeted interventions directed toward high-risk inpatients have become an important strategy to optimize resource utilization and **patient safety.** Objective: This review synthesizes recent evidence on **pharmacist-led medication review** and **risk-stratification** approaches in acute care settings, with emphasis on intervention design, implementation mechanisms, and associations with **clinical and economic outcomes**. Methods: A systematic narrative review of peer-reviewed literature published between 2015 and 2025 was conducted using PubMed, Scopus, and Web of Science databases. Search terms included pharmacist-led medication review, prioritization tools, high-risk patients, hospital interventions, and clinical outcomes. Results: Multifaceted pharmacist-led interventions combining medication reconciliation, comprehensive review, prescriber engagement, and post-discharge follow-up demonstrate consistent reductions in medication-related problems (49–88% resolution rates), unplanned hospital readmissions (7–15% relative reduction), and emergency department revisits. Risk-stratification tools effectively target complex patients, shifting pharmacist effort toward those with highest need.

Economic evaluations indicate favorable return on investment, with cost avoidance ranging from $447 to $2,799 per intervention and return on investment ratios exceeding 5:1 in critical care settings. Conclusions: Evidence supports implementation of prioritized pharmacist-led medication reviews as a cost-effective intervention for high-risk inpatients. Future research should establish **standardized outcome** measures, validate **risk-prediction algorithms** across diverse healthcare systems, and integrate pharmacist-led services into electronic health record workflows to enable scalable, data-driven **clinical pharmacy practice**.

KEYWORDS: Medication review, pharmacist interventions, medication safety, polypharmacy, risk stratification, hospital readmission, clinical outcomes, cost-effectiveness.

INTRODUCTION:

Adverse drug events and medication-related problems constitute one of the most common categories of preventable hospital complications, contributing significantly to patient morbidity, prolonged hospitalization, and excess healthcare expenditure[1–3].The hospitalized population is particularly vulnerable to medication-related harm due to acute physiologic instability, complex therapeutic regimens, limited time for patient counseling, and frequent care transitions across hospital units and post-discharge settings[4,5]. Polypharmacy defined as concurrent use of five or more medications further amplifies medication risk through increased potential for pharmacokinetic interactions, duplicate therapy, and inappropriate drug selection in the context of reduced renal or hepatic function [2,6]

Clinical pharmacists occupy a unique position within the healthcare team to identify, prevent, and resolve medication-related problems through comprehensive medication review, evidence-based recommendations, and direct patient education [7]. Over the past two decades, the body of evidence supporting pharmacist-led interventions in hospital settings has expanded substantially, with systematic reviews documenting improvements in medication appropriateness, adherence, and intermediate clinical endpoints [1,8].

This review aims to:

- Describe contemporary models of pharmacist-led medication review in acute and immediate post-discharge care settings
- Examine risk-stratification criteria and decision-support tools used to prioritize high-risk patients

- Synthesize evidence linking these interventions to clinically relevant outcomes, including medication-related problems, adverse drug events, hospital readmissions, length of stay, and healthcare costs
- Identify mechanistic pathways, implementation barriers, and gaps in current knowledge pertinent to future clinical pharmacy service development.

CONCEPTUAL FRAMEWORKS AND DEFINATIONS

Medication Review: Classification and Components:

Medication review is fundamentally a systematic, interdisciplinary process of evaluating a patient's entire medication regimen to optimize therapeutic efficacy, minimize medication-related harm, and align treatment with patient values and preferences [9,10]. Contemporary frameworks classify medication reviews across three hierarchical levels based on complexity and clinical integration:

Level 1: Technical Review: A prescription-focused evaluation examining medication appropriateness relative to dosing guidelines, frequency, formulation, and obvious contraindications, typically conducted without patient interaction or detailed clinical assessment.

Level 2: Treatment Review: Integration of clinical information including laboratory values, vital signs, and disease severity to evaluate indication appropriateness, therapeutic duplication, and the necessity of continued therapy.

Level 3: Comprehensive/Clinical Review: The most intensive level, incorporating direct patient interviews, shared decision-making regarding medication goals and preferences, assessment of adherence barriers, identification of adverse drug effects, and structured follow-up to ensure recommendations are implemented [9].

Recent scoping reviews indicate substantial heterogeneity in medication review practice, with most contemporary inpatient interventions incorporating elements across these three categories as part of integrated clinical pharmacy services rather than isolated activities [9,11]. The specific combination of review components-medication reconciliation, patient counseling, prescriber communication, and post-discharge follow-up-appears to be a critical determinant of clinical effectiveness.

High-Risk Inpatients and Risk Stratification:

High-risk inpatients are those patients for whom medication-related problems pose a substantially elevated probability of adverse outcomes, including in-hospital mortality, unplanned readmission, emergency department revisit, or accelerated functional decline [12,13].

Risk factors operate across multiple domains:

Patient-level factors: Advanced age (≥75 years), cognitive impairment, multiple chronic conditions (comorbidity burden), frailty, and recent intensive care unit stay or emergency department presentation.

Treatment-level factors: Polypharmacy (≥5 regular medications), exposure to high-risk drug classes (anticoagulants, antiplatelets, insulin, narrow-therapeutic-index agents, psychoactive medications), abnormal laboratory values suggesting organ dysfunction (renal insufficiency, hepatic impairment), and documented prior adverse drug reactions.

System-level factors: Recent hospitalization, frequent emergency department use, discharge to congregate living facilities, limited health literacy, and lack of primary care follow-up.

Risk-stratification tools operationalize these factors through explicit scoring systems or categorical priority levels embedded within pharmacy workflow systems to guide resource allocation. A well-designed tool should balance sensitivity (identifying most at-risk patients) against feasibility (not exceeding available pharmacist capacity), typically targeting the 20–40% of hospitalized patients most likely to experience medication-related complications [12,14].

CONTEMPORARY EVIDENCE ON PHARMACIST-LED MEDICATION REVIEW

Scoping Review of Systematic Reviews:

A comprehensive 2024 scoping review examining 24 systematic reviews of pharmacist-led medication reviews across diverse settings and populations documented substantial heterogeneity in intervention design, outcome measurement, and reported effects[9].Despite this variability, two methodologically rigorous reviews reported meaningful reductions in hospital readmissions (relative risk 0.93; 95% confidence interval 0.89–0.98), representing approximately a 7% absolute reduction in unplanned readmission rates[9,11].

Across included reviews, identification of medication-related problems demonstrated remarkable consistency, with 49–88% of identified problems being subsequently resolved through pharmacist recommendations [9,13,15]. Improvements in process measures including prescribing appropriateness, medication adherence monitoring, and guideline concordance

occurred uniformly across study populations and care settings. Conversely, evidence for reduction in all-cause hospital mortality was inconsistent and generally not statistically significant, likely reflecting the fact that many in-hospital deaths stem from non-medication factors beyond pharmacotherapy optimization [9,13].

Multifaceted Hospital-Based Interventions:

Systematic evidence from 28 randomized and observational studies of multifaceted, hospital-based pharmacist interventions (published 2006–2018) identified core components consistently associated with clinical benefit. These interventions typically integrated medication reconciliation at admission, comprehensive medication review incorporating clinical assessment and patient interviews, structured communication of recommendations to prescribers, patient education at discharge, and proactive telephone follow-up within 7–14 days post-discharge[1].

Approximately 61% of reviewed studies documented significant improvements in medication use quality, while 44% reported quantifiable reductions in unplanned hospital visits or readmission rates [1]. When interventions included explicit follow-up contact (telephone counseling, clinic visit) in the immediate post-discharge period, readmission reductions were more pronounced, suggesting that post-discharge continuity of care is a critical intervention component [1,16].

Post-Discharge Pharmacist Interventions:

A 2023 systematic review synthesizing 17 studies of hospital-based post-discharge pharmacist medication reviews identified three predominant clinic models: pharmacist review alone, integrated inpatient plus post-discharge pharmacist review, and collaborative pharmacist-physician post-discharge clinics[17]. Across these models, the most frequently implemented interventions included medication reconciliation (100% of studies), identification of medication-related problems (88%), and structured communication with primary care providers (71%)[17]

Remarkably, 71% of included studies reported significant reductions in readmission rates, with effect sizes ranging from 4% to 22% relative risk reduction. Post-discharge interventions conducted within 7 days of hospital discharge demonstrated larger readmission reductions (mean 14.2%) compared with those initiated beyond 2 weeks (mean 6.8%), establishing the clinical importance of early, intensive follow-up[17].

RISK STRATIFICATION AND PRIORITIZATION TOOLS

Development of Clinical Prioritization Algorithms:

Contemporary hospital pharmacy practice increasingly employs explicit prioritization tools to direct pharmacist resources toward patients with the highest expected benefit. A formative study developing and implementing a clinical prioritization tool in a large tertiary-care teaching hospital used systematic input from front-line clinical pharmacists, pharmacy leaders, and expert review to establish objective priority criteria[18].These criteria incorporated:

- Exposure to high-risk medicines or significant drug–drug or drug–disease interactions.
- Abnormal laboratory results associated with increased medication risk (renal dysfunction, hepatic impairment, electrolyte abnormalities).
- Diagnosis-specific high-risk conditions (acute decompensated heart failure, acute kidney injury, sepsis).
- Patient factors including age, polypharmacy burden, and functional status.
- Automatic elevation to Level 1 (highest priority) for patients with recent intensive care unit discharge.

Validation of this tool demonstrated sensitivity ranging from 51% to 88% for identifying patients requiring intensive pharmaceutical care, with implementation resulting in significant shifts in pharmacist activity distribution: increasing time spent with Level 1 complex patients and reducing time allocated to lower-acuity Level 3 patients [18]. Implementation feedback highlighted the importance of electronic integration, with pharmacist buy-in and acceptance enhanced when prioritization occurred automatically within existing pharmacy workflow systems rather than requiring manual patient triage.

High-Needs Pharmacy Criteria and Predictive Validity:

Parallel work in Australian hospital networks developed “high-needs pharmacy criteria” to prospectively identify inpatients at elevated risk of medication-related complications and 30-day unplanned readmission[14].Patients meeting these criteria demonstrated a sensitivity exceeding 80% for subsequent adverse medication outcomes, with significantly longer baseline hospital lengths of stay, greater medication complexity, and higher prevalence of identified medication-related problems compared with standard-risk patients [14].

These high-needs patients were characterized by:

(1)Age ≥75 years combined with ≥10 regular medication

(2)Exposure to ≥3 high-risk medications regardless of age

(3)Acute decompensation of a chronic disease state (4)Previous documented medication-related adverse event [14].

Prospective application of these criteria enabled pharmacists to concentrate 65–75% of their clinical time on the 25–35% of patients meeting high-needs thresholds, substantially improving resource efficiency [14,19].

Electronic Health Record Integration and Automation:

Successful implementation of risk-stratification tools requires integration into existing electronic health record and pharmacy management systems to enable automatic flagging and visibility within daily pharmacist workflow [18,20]. Manual approaches to patient identification are labor-intensive and subject to inconsistent application, whereas electronic automation ensures consistent criteria application and facilitates real-time workload management across pharmacy teams.

Integration challenges include: data quality issues (incomplete medication lists, inaccurate laboratory values), lack of interoperability between disparate clinical systems, and variability in electronic health record architecture across institutions [20].Enablers of successful implementation include pharmacy leadership commitment, involvement of informatics pharmacists during tool development and validation, iterative refinement based on user feedback, and explicit resource allocation for technical support and staff training [18,21].

INTERVENTION COMPONENTS AND MECHANISTIC PATHWAYS

Core Components of Effective Interventions:

Analysis of published pharmacist-led inpatient interventions reveals a consistent constellation of core components, each contributing to overall clinical effectiveness:

Medication Reconciliation:

Systematic comparison of medication lists across clinical, pharmacy, and community records to identify and resolve unintentional discrepancies. Implementation at admission detects medications inadvertently omitted during emergency prescribing or erroneously continued despite prior adverse reactions; reconciliation at discharge prevents medication gaps and therapeutic duplications that contribute to post-discharge destabilization [16,22].

Comprehensive Medication Review:

Chart-based and clinical assessment addressing appropriateness of each medication's indication, dose, duration, potential for therapeutic duplication, and likelihood of adverse drug events given the patient's clinical status, laboratory values, and concomitant medications. Reviews explicitly evaluate high-risk drug–drug interactions, dosing adjustments for renal/hepatic dysfunction, and appropriateness of dose escalations or de-intensifications during acute illness [13,15].

Prescriber Communication and Feedback:

Direct, respectful communication of pharmacist recommendations to prescribers through written documentation, ward rounds, or structured communication formats (e.g., SBAR framework: Situation, Background, Assessment, Recommendation). Research demonstrates that recommendations conveyed through direct discussion rather than passive documentation achieve substantially higher acceptance rates (70–85% versus 40–50%)[1,15].

Patient Counseling and Education:

Structured patient interviews addressing medication purposes, expected effects, management of side effects, adherence strategies, and recognition of warning signs necessitating urgent evaluation. Patient education incorporating teach-back methodology wherein patients explain back to the pharmacist their understanding of critical medication information improves comprehension and subsequent adherence compared with unidirectional instruction [16,23].

Post-Discharge Follow-Up:

Proactive telephone contact or clinic visit within 7–14 days following hospital discharge to reinforce medication understanding, address adherence barriers, screen for early signs of medication-related complications, and facilitate communication with outpatient providers regarding changes made during hospitalization [16,17].

Mechanistic Pathways to Improved Clinical Outcomes:

Pharmacist-led medication review improves patient outcomes through several interconnected mechanistic pathways:

Error Prevention:

Identification and prescribing, dispensing, and administration errors before they result in patient harm. Pharmacists' detailed knowledge of medication metabolism, interactions, and

contraindications enables detection of high-risk combinations or dosing errors that may escape notice during prescriber ordering or nursing administration [1,15]

Optimization of Pharmacotherapy:

Dose adjustments in renal/hepatic impairment, avoidance of contraindicated agents in patients with specific disease states (e.g., angiotensin-converting enzyme inhibitors in pregnancy or acute renal failure), and selection of agents with favorable risk benefit profiles in older adults reduce disease complications, treatment failures, and adverse drug effects [13,24].

Deprescribing and De-escalation:

Identification and discontinuation of potentially inappropriate medications, including agents beyond indicated duration, medications duplicating therapy, and drugs carrying high risk in context of patient age or comorbidity. Deprescribing reduces pill burden, simplifies regimens to improve adherence, decreases medication costs, and eliminates unnecessary adverse drug exposure [24,25].

Enhanced Adherence:

Patient education, simplified regimen design, removal of barriers to medication administration (e.g., difficulty swallowing, prohibitive cost), and follow-up reinforcement improve medication adherence, which is particularly critical in chronic disease management and prevention of acute exacerbations [23,24]

Improved Care Continuity:

Structured communication between inpatient and outpatient providers, documentation of medication changes and clinical rationale, and early post-discharge follow-up reduce information loss during transitions, preventing reinitiation of discontinued medications or failure to implement important therapeutic changes [16,22].

CLINICAL OUTCOMES IN HIGH-RISK INPATIENT POPULATIONS

Hospital Readmissions and Emergency Department Revisits:

Evidence for reduction in hospital readmissions represents the most consistently favorable clinical outcome associated with pharmacist-led medication review. A scoping review of 25 studies specifically examining pharmacist-led interventions at hospital discharge identified readmission reductions in 71% of included studies, with absolute reductions ranging from 4%

to 22%[16]. Meta-analytic synthesis of high-quality randomized trials yielded a relative risk reduction of 7% (95% confidence interval 2–12%), translating to prevention of approximately 1 readmission per 14–20 high-risk patients receiving intensive pharmacist intervention [9]

Magnitude of readmission reduction is substantially larger when post-discharge follow-up components are implemented particularly telephone contact within 7 days compared with interventions limited to inpatient review and discharge counseling alone [16,17].This finding underscores the critical importance of continuity beyond hospital walls: many medication problems manifest days to weeks following discharge as patients resume activities of daily living, encounter medication side effects, or fail to adhere to complex regimens without reinforcement and support[16]

Reductions in emergency department revisits, while less frequently reported, are consistently observed when intensive medication review and post-discharge follow-up are implemented. These visits, which frequently result from easily preventable complications such as medication adherence lapses, adverse drug effects, or inadequate monitoring of disease control parameters, are substantially reduced through pharmacist intervention [17].

Length of Hospital Stay and Resource Utilization:

Pharmacist-led interventions demonstrate variable but generally favorable effects on length of hospital stay. Approximately 35–40% of published studies report statistically significant reductions in hospitalization duration, ranging from 1 to 4 additional hospital days avoided through optimization of medication therapy, early recognition and management of medication-related complications, and facilitation of discharge planning[1,13].

In intensive care unit populations, where medication complexity is particularly high and medication errors carry elevated consequence, pharmacist interventions are associated with reductions in critical care stay duration. One well-executed study documented that critical care pharmacists' medication reviews and interventions prevented 73 intensive care unit days, 74 days of intensive continuous monitoring, and 66 conventional hospital days, yielding estimated direct cost savings of €252,000 and a return on investment exceeding €5 per €1 invested in pharmacist services [26].

Medication-Related Adverse Events and Problem Resolution:

Identification and resolution of medication-related problems represents perhaps the most consistent outcome documented across pharmacist-led medication review studies. Problem resolution rates defined as implementation of pharmacist recommendations by prescribers range from 65% to 88%, with the highest acceptance rates observed for recommendations addressing obvious dosing errors or contraindicated drug combinations [1,9,15].

Serious adverse drug events preventable through medication review (e.g., hyperkalemia from angiotensin-converting enzyme inhibitor and spironolactone combination in renal failure, hypoglycemia from insulin continued without carbohydrate intake) are substantially reduced through systematic pharmacist review, particularly in high-risk populations such as older adults and patients with multiple chronic diseases [13,26].

Mortality and Other Clinical Endpoints

Effects on all-cause hospital mortality are notably inconsistent across published studies, with most systematic reviews finding no statistically significant mortality differences between patients receiving pharmacist-led medication review versus standard care [1,9,13].This reflects the reality that in-hospital mortality stems from multiple etiologic factors beyond medication optimization (infection severity, acute organ failure, cardiopulmonary complications), and while pharmacist interventions improve medication safety, they do not address these fundamental drivers of fatal outcomes [1].

More consistently favorable effects are observed for intermediate clinical endpoints relevant to specific disease populations. For example, in patients with heart failure or acute coronary syndrome, pharmacist-led interventions improve medication adherence and reduce unplanned readmissions; in diabetic patients, reviews optimize glycemic control; in hypertensive populations, pharmacist counseling improves blood pressure management [1,7].

ECONOMIC OUTCOMES AND COST-EFFECTIVENESS

Direct Cost Savings and Cost Avoidance:

Multiple hospital-based economic evaluations document substantial cost avoidance attributable to pharmacist-led medication review, primarily through prevention of medication-related adverse events and avoided hospital readmissions. A six-year evaluation across multiple hospital sites documented 19,240 pharmacist interventions across 492,612 patient reviews, achieving 88.63% resolution of drug therapy problems and generating estimated

total cost avoidance of $8.60 million (EGP 265.32 million) with average cost avoidance per intervention of $447 (EGP 13,790) [27].

In critical care populations, cost avoidance is particularly substantial, reflecting the high daily costs of intensive care. A single-center critical care evaluation calculated average cost avoidance of $2,799 per pharmacist intervention in critically ill patients compared with $68 in non-critically ill inpatients, with cumulative cost avoidance of $252,000 over a single year from a single-center clinical pharmacy service [26,28].

Community and primary care pharmacist-led medication reviews demonstrate similar patterns of cost avoidance. Post-discharge comprehensive medication reviews completed within primary care settings generate cost savings through reduced readmission utilization, with some analyses documenting return on investment ratios exceeding 5:1 [29,30].

Return on Investment and Cost-Effectiveness Ratios:

Economic analyses consistently demonstrate favorable return on investment for clinical pharmacy services, with the ratio of cost avoidance to intervention costs ranging from 5:1 to 760% (cost avoidance equivalent to 5–7.6 times the cost of the intervention)[27,28,31].These favorable ratios hold across diverse healthcare settings and patient populations, from hospital inpatient care to outpatient chronic disease management.

Importantly, cost avoidance accrues primarily through prevention of serious medication-related adverse events (estimated at $2,000–5,000 per event prevented), avoided hospital readmissions ($10,000–15,000 per readmission prevented), and prevention of preventable adverse drug events that prolong hospitalization [26,28,31]. These mechanisms explain why intervention cost-effectiveness is particularly pronounced in high-risk populations where medication-related complications are common and high-cost consequences of failure are substantial.

Methodological Considerations and Limitations:

Despite favorable reported return on investment ratios, economic evaluations of clinical pharmacy interventions face substantial methodological limitations that warrant consideration when interpreting cost-effectiveness evidence [27,31].Many analyses rely on estimated cost avoidance based on literature values rather than actual observed healthcare utilization data, introducing uncertainty regarding true economic impact. Single-center studies may not

generalize across healthcare systems with different cost structures, case mixes, or operational models. Incomplete capture of intervention costs particularly pharmacist time for post-discharge follow-up, documentation, and team communication may artificially inflate calculated return on investment ratios [27].

Heterogeneity in cost frameworks, currencies, and healthcare system structures complicates cross-study comparison and meta-analysis. Despite these methodological constraints, the consistency of cost-avoidance findings across diverse settings and the magnitude of estimated returns on investment (uniformly exceeding 1:1) provide strong evidence that pharmacist-led medication review is economically attractive, even under conservative assumptions regarding cost avoidance assumptions and intervention success rates.

IMPLEMENTATION SCIENCE: BARRIERS, ENABLERS, AND TRANSLATIONAL CHALLENGES

Intervention Characterization and Standardization:

A foundational implementation challenge is that pharmacist-led medication reviews are frequently described incompletely in published reports, limiting reproducibility and hampering translation to new settings [9,11].Insufficient specification of core components, intervention duration, frequency, and contextual factors (e.g., pharmacist training level, integration into workflow, interprofessional collaboration intensity) contributes to heterogeneity in reported outcomes and complicates attempts at standardization across institutions.

Frameworks such as DEPICT (Descriptive Elements of Pharmacist Intervention Characterization Tool) have emerged to systematically capture intervention content, intensity, delivery mechanisms, and implementation context in perioperative and acute care settings [1].Broader adoption of such characterization frameworks could substantially improve intervention transparency, facilitate comparative effectiveness research, and enable more reliable meta-analysis of pharmacist interventions across diverse settings and populations.

Workflow Integration and Information Technology Implementation:

Effective implementation of risk-stratification and pharmacist-led medication review depends critically on seamless integration into existing electronic health record and pharmacy management workflows [18,20,21].When prioritization tools require manual patient identification and separate documentation systems, pharmacist adoption is inconsistent, and

clinical implementation is fragmented. Conversely, when tools are embedded directly into existing pharmacy systems with automatic flagging and visible prioritization in routine daily workflow, adoption and adherence are substantially improved [18].

Technological barriers to successful implementation include: data quality problems (incomplete medication reconciliation, inaccurate laboratory values), lack of interoperability between hospital pharmacy systems and broader hospital electronic health records, variation in electronic health record vendor platforms across institutions, and insufficient information technology support for customization and troubleshooting[20,21].

Organizational and workflow barriers include: perception by pharmacists and other clinicians that electronic prioritization is inflexible or misses important clinical nuance, lack of clear guidance regarding appropriate action when patients meet multiple priority criteria and available pharmacist time is limited, and resistance from front-line staff to workflow modifications required for tool implementation[18].

Successful implementations address these barriers through: early and sustained engagement of front-line clinical staff in tool development and refinement, clear communication of tool development rationale and evidence base, real-time feedback mechanisms to detect and address tool performance problems, and explicit organizational commitment to support successful implementation through leadership endorsement, staff training, and resource allocation[18,21].

Workforce Development and Interprofessional Collaboration:

Implementation and scaling of pharmacist-led medication review services requires sustained investment in workforce development and cultivation of interprofessional collaborative relationships. Advanced clinical skills including assessment of medication appropriateness in complex patients, recognition of subtle adverse drug effects, and negotiation of deprescribing decisions with resistant patients demand ongoing clinical education and access to specialists experienced in clinical pharmacy practice.

Trust and productive working relationships with physicians and other prescribers are particularly critical. Prescriber acceptance of pharmacist recommendations averages 70–85% for obvious dosing corrections or contraindicated combinations but drops to 40–50% for recommendations affecting prescriber decision-making autonomy (e.g., deprescribing or de-

intensification of therapy)[1,15].High-performing clinical pharmacy services invest substantially in relationship-building, including proactive ward round participation, transparent communication regarding recommendation rationale, and recognition of prescriber expertise in clinical decision-making[1,7].

Organizational culture and leadership are equally important determinants of successful implementation. Healthcare systems that position clinical pharmacy as a core patient safety function with explicit operational and strategic importance achieve more rapid and complete implementation of pharmacist-led services compared with institutions where pharmacy is viewed as a support or transactional function[21,32].

COMPARATIVE ANALYSIS AND CONTEXTUAL VARIATIONS

Differential Impact Across Patient Populations and Care Settings:

Pharmacist-led medication review demonstrates differential clinical impact across distinct patient populations and hospital care settings. Older adults (particularly those ≥75 years) with multiple chronic conditions and polypharmacy experience more substantial medication-related problems and achieve greater absolute benefit from comprehensive medication review compared with younger patients with limited comorbidity[15,24].

In intensive care unit populations, where medication use is particularly complex and error consequences are high, pharmacist interventions demonstrate pronounced effects on clinical outcomes and cost avoidance[26,28].Conversely, in lower-acuity settings with straightforward therapeutic regimens, pharmacist review identifies fewer clinically significant problems and achieves more modest impact on readmission rates and costs.

Hospital-based interventions demonstrate larger readmission reductions when targeted at specific high-risk discharge scenarios such as patients with acute decompensated heart failure, recent acute myocardial infarction, or community-acquired pneumonia compared with generic pharmacist review applied universally to all hospitalized patients[16,17].This supports the argument for targeted, condition-specific pharmacist services rather than one-size-fits-all implementation models[18].

International Variations in Implementation and Evidence Base:

Pharmacist-led medication review practice and supporting evidence vary substantially across international healthcare systems reflecting differences in:

- Pharmacy workforce size and educational preparation
- Regulatory scope of practice for pharmacists
- Healthcare financing models and incentive structures
- Electronic health record maturity and integration
- Cultural acceptance of expanded pharmacist roles.

In Nordic countries and the United Kingdom, with mature clinical pharmacy education infrastructure and explicit policy support for pharmacist clinical roles, implementation of medication review services is widespread and evidence bases are relatively robust[1,9,33].In contrast, in many low- and middle-income countries where pharmacy practice is traditionally focused on dispensing and where pharmacist-to-patient ratios are constrained, clinical pharmacy services are nascent despite high medication-related problem prevalence[27,34].

A 2024 systematic review of pharmacist-led medication review in older adults across United Kingdom and Ireland health systems documented consistent clinical benefit, with 12 of 14 included studies reporting positive outcomes including reductions in potentially inappropriate medications, adverse drug reactions, and medication-related falls.[35] This geographic consistency in positive findings lends confidence to the generalizability of pharmacist-led medication review benefits across developed healthcare systems with comparable pharmacy infrastructure.

CURRENT GAPS AND FUTURE RESEARCH DIRECTIONS

Standardization of Outcome Measurement and Core Outcome Sets:

Current heterogeneity in outcome measurement across pharmacist-led medication review studies substantially limits comparability and meta-analytic synthesis. Different studies employ varied definitions of “medication-related problem,” assess adherence through different methodologies, and report clinical outcomes (readmissions, length of stay, mortality) using inconsistent follow-up windows and denominator specifications.

Development and adoption of core outcome sets standardized, consensus-derived batteries of outcomes relevant to key stakeholders (patients, clinicians, health systems) would substantially improve evidence synthesis and enable rigorous comparative effectiveness analysis [36]. Recommended core outcomes should encompass:

- Drug-related problems identified and resolved
- Medication-related adverse events prevented

- Unplanned hospital readmissions within 30 days
- Emergency department revisits
- Medication adherence
- Patient-reported quality of life
- Healthcare costs and cost-avoidance estimates with transparent methodology [36].

Validation of Risk-Prediction and Prioritization Tools:

While initial studies of pharmacist prioritization tools demonstrate promising sensitivity and specificity for identifying high-risk patients, substantial gaps remain in knowledge regarding optimal risk thresholds, comparative effectiveness of different algorithmic approaches, and generalizability across diverse patient populations and healthcare systems [14,18,19].

Future research should include:

1. Multicenter, prospective validation studies of existing prioritization tools across diverse hospital settings
2. Comparative effectiveness studies pitting rule-based algorithms against machine-learning–based risk prediction
3. Evaluation of the clinical and economic impact of different risk thresholds on pharmacist resource allocation
4. Assessment of potential algorithmic bias and differential performance across demographic groups (age, race/ethnicity, socioeconomic status) to ensure equitable application of prioritization criteria [14,19,35].

Implementation Science and Scalability Research:

Despite growing evidence of pharmacist-led medication review effectiveness, implementation in many hospital systems remains inconsistent and suboptimal. Implementation science research using established frameworks (Consolidated Framework for Implementation Research, RE-AIM) can identify context-specific barriers and facilitators, characterize implementation strategies most effective in different organizational contexts, and establish methods for monitoring and evaluating implementation success[21,32].

Hybrid effectiveness-implementation trials that simultaneously evaluate clinical effectiveness while observing real-world implementation processes represent an underutilized design that could substantially advance the field. Such trials would document not only whether pharmacist-led medication review improves patient outcomes under ideal conditions, but how

to successfully implement these services in typical hospital environments with realistic resource constraints and organizational challenges [21,32].

Integration with Deprescribing, Polypharmacy Management, and Precision Medicine:

Emerging evidence regarding pharmacist-led deprescribing interventions systematic discontinuation of potentially inappropriate medications with shared decision-making suggests potential to amplify benefits of medication review through proactive medication reduction [24,25,35]. Future research should evaluate optimal strategies for integration of deprescribing alongside medication optimization, including patient education approaches that address fear of medication discontinuation and shared decision-making processes that incorporate patient preferences.

Precision medicine approaches, incorporating pharmacogenomic testing and individualized risk assessment, represent an emerging frontier for pharmacist-led medication optimization. Clinical pharmacists are increasingly positioned to interpret pharmacogenomic results and translate them into individualized dosing recommendations and drug selection decisions [36,37].Research examining how pharmacogenomic-informed pharmacist recommendations affect adherence, adverse drug event rates, and clinical outcomes in real-world hospital settings remains limited but represents a promising avenue for personalized medication optimization.

CONCLUSIONS:

Pharmacist-led medication review, particularly when implemented as part of multifaceted interventions incorporating medication reconciliation, patient counseling, prescriber engagement, and post-discharge follow-up, represents a well-supported strategy for improving medication safety and reducing preventable hospital complications in high-risk inpatient populations. Contemporary evidence demonstrates consistent reductions in medication-related problems (49–88% resolution), unplanned hospital readmissions (7–15% relative reduction), and identified medication-related adverse events.

Economic analyses consistently document favorable return on investment, with cost avoidance per intervention ranging from $447 to $2,799 and cumulative returns on investment exceeding 5:1. Risk-stratification and prioritization tools effectively direct pharmacist resources toward patients at highest risk of medication-related complications, improving efficiency and focusing clinical effort where benefit is greatest.

Despite this favorable evidence base, substantial opportunities exist for advancement. Standardization of intervention components and outcome measurement, multicenter validation of risk-prediction algorithms, and implementation science research examining scalability across diverse healthcare systems are essential priorities. Integration of pharmacist-led services with emerging approaches including deprescribing, pharmacogenomic-informed precision medicine, and advanced electronic health record decision support represents the frontier of clinical pharmacy practice development.

Healthcare systems seeking to optimize medication safety and efficiency should invest in explicit prioritization of pharmacist-led medication review for high-risk inpatients, with particular emphasis on post-discharge follow-up to extend benefits beyond hospitalization. Future clinical pharmacy practice will increasingly integrate advanced risk prediction, real-time electronic decision support, and collaborative care models that position pharmacists as central members of multidisciplinary teams engaged in comprehensive medication optimization across the care continuum.

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