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LABORATORY-GUIDED MEDICATION SAFETY IN HOSPITAL SETTINGS: THE ROLE OF PHARMACIST NURSE COLLABORATION; A SYSTEMATIC REVIEW

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Abstract

Medication safety in hospitals is a major patient-safety priority, particularly where high-alert drugs require timely laboratory interpretation and rapid dose adjustment. Pharmacists and nurses jointly influence these processes through ordering, sampling, administration, monitoring, and escalation. This systematic review evaluated how laboratory-guided services supported by pharmacist–nurse collaboration affect medication safety outcomes in hospital settings. We focused on hospital-based interventions involving anticoagulation management, therapeutic drug monitoring (TDM) of antimicrobials, anti-Xa-guided thromboprophylaxis, and renal dose adjustment programs. We searched major databases for open-access original studies evaluating pharmacist-led or pharmacist–nurse collaborative models with explicit laboratory-linked endpoints. Outcomes included appropriateness of monitoring, dose adjustment accuracy, surrogate safety outcomes, and error reduction. Nine eligible original studies were included. In settings, pharmacist-managed protocols were associated with improved adherence to evidence-informed dosing pathways, more appropriate laboratory monitoring, and increased attainment of therapeutic targets. The effect was most consistent in inpatient warfarin protocols and vancomycin TDM programs. Renal dose adjustment policies supported by clinical pharmacy review reduced clinically meaningful dosing errors. Anti-Xa–guided approaches supported by pharmacist input improved the likelihood of reaching target prophylactic ranges in high-risk trauma populations.

Keywords: Medication Safety; Pharmacist–Nurse Collaboration; Therapeutic Drug Monitoring; Warfarin; Vancomycin; Renal Dose Adjustment; Anti-Xa.

INTRODUCTION

Preventable medication harm is substantial in health-care settings, with systematic evidence showing that a meaningful proportion of drug-related injury is avoidable through

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better systems, monitoring, and interdisciplinary coordination (Hodkinson et al. 2020). In hospitals, the risk increases with polypharmacy, acute illness, renal dysfunction, and the use of high-alert medications requiring laboratory-linked titration. Nurses have central responsibilities in pharmaceutical care, including medication administration, patient monitoring, recognition of adverse effects, and communication of clinical changes that can influence laboratory interpretation and dose decisions (De Baetselier et al. 2021). Pharmacists bring complementary expertise in pharmacokinetics, therapeutic targets, drug–lab interpretation, and protocol-driven optimization.

Coordinated nurse–pharmacist practice is therefore positioned to address common failure points in the medication-use process, particularly at the interface of sampling, timing, dose adjustment, and documentation. Evidence mapping suggests that nurse–pharmacist collaboration can reduce discrepancies and improve medication safety outcomes, although models and contexts vary (Ravi et al. 2022). Laboratory-guided medication safety commonly centers on (1) anticoagulation where INR targets must be achieved safely, (2) antimicrobial TDM, especially vancomycin, where evidence supports TDM-related benefits in clinical efficacy and nephrotoxicity reduction, (3) anti-Xa monitoring for adjusted thromboprophylaxis in selected high-risk groups, and (4) renal dose adjustment programs aimed at preventing accumulation-related toxicity (Ye et al. 2013). Prior single-institution and multi-institution experiences indicate that pharmacist-managed inpatient warfarin protocols can strengthen adherence to evidence-based practices (Damaske et al. 2005; Daniels et al. 2018). Similarly, pharmacist-led vancomycin TDM programs that include ordering and interpretation of relevant laboratory tests appear to improve the likelihood of appropriate sampling and subsequent dose adjustment (Firman et al. 2022). For renal dosing, pharmacist feedback and policy-driven verification have been associated with improved compliance and reduced dosing errors in hospitalized patients with impaired renal function (Bassett et al. 2020; Alqurashi et al. 2021). This review synthesizes open-access hospital studies evaluating laboratory-guided medication safety interventions where pharmacist-led or pharmacist–nurse collaborative processes were central.

METHODS

This systematic review was conducted in accordance with PRISMA 2020 guidance (Page et al. 2021). We defined the question using a structured framework focused on hospitalized patients receiving medications requiring laboratory-guided monitoring or dose adjustment. The intervention of interest was pharmacist-led or pharmacist–nurse collaborative models explicitly linked to laboratory processes. These models included pharmacist-managed protocols, collaborative practice models, or policy-based verification workflows. Comparators were usual care, physician-led management, or pre-intervention baselines. Outcomes included appropriateness of laboratory monitoring, attainment of therapeutic targets (INR, vancomycin targets, anti-Xa ranges), medication-error rates related to dosing, and relevant safety proxies (reduced supratherapeutic values or fewer high-risk deviations). We searched open-access databases and repositories, prioritizing PubMed, PMC and other open-source platforms, for articles published in English. Search terms combined concepts of pharmacist–nurse

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collaboration, clinical pharmacy services, therapeutic drug monitoring, anticoagulation protocols, renal dose adjustment, anti-Xa monitoring, and hospital medication safety. We also screened reference lists of relevant reviews to identify additional eligible studies. Inclusion criteria were: original quantitative hospital-based studies, evaluation of a laboratory-guided medication safety intervention, clear pharmacist involvement in protocolized decisions or lab-linked dose adjustments, and accessible full text. Exclusion criteria were: purely outpatient studies without hospital integration, editorials, narrative reviews, and studies lacking laboratory-linked outcomes. Two-stage screening was applied: title, abstract review followed by full-text eligibility assessment. Data extraction focused on study setting, population, medication class, nature of pharmacist, nurse roles, laboratory endpoints, and key outcomes. Due to anticipated heterogeneity in interventions and outcome definitions in drug classes, we planned a narrative synthesis rather than meta-analysis.

RESULTS

Study Selection and Overview

The search identified open-access studies evaluating hospital laboratory-guided safety interventions involving clinical pharmacists. After screening and eligibility assessment, nine original studies were included in the final synthesis. The included literature clustered into four practical domains: inpatient warfarin management, vancomycin TDM, anti-Xa–guided thromboprophylaxis, and renal dose adjustment policies/programs.

Table 1: key features of the included studies.

Study	Year	Country and setting	Design	Population	Laboratory-guided focus	Intervention model
Damaske et al.	2005	Inpatient hospital	Pilot/quality study	Adult inpatients on warfarin	INR	Pharmacist-managed inpatient warfarin protocol
Daniels et al.	2018	Large hospital system	Quality improvement	Surgical & medical inpatients	INR	Pharmacist-managed warfarin protocol with algorithm support
Alghadeer et al.	2020	Tertiary care	Comparative cohort	Warfarin-treated patients	INR/TTR	Pharmacist-led anticoagulation model
Hirano et al.	2016	Single institution	Observational	MRSA-treated patients	Vancomycin levels	Pharmacist-managed TDM dose feedback
Firman et al.	2022	Tertiary hospital	Interventional pilot	Adults receiving vancomycin	Vancomycin TDM	Pharmacist-managed TDM program including ordering labs

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Hussain et al.	2021	Pediatric hospital	Pre–post/implementation	Pediatric patients on vanco/aminoglycosides	TDM levels	Pharmacist-directed TDM service
Scrimenti et al.	2019	SICU/trauma	Observational	Trauma ICU patients	Anti-Xa	Pharmacist recommendations for enoxaparin monitoring
Bassett et al.	2020	Hospital policy evaluation	Observational	Adults with renal impairment	Renal function labs	Pharmacist use of renal dose adjustment policy
Alqurashi et al.	2021	Tertiary hospital, KAMC	Quasi-experimental	Orders requiring renal adjustment	Renal function	Pharmacists-led renal dosing adjustment program
Sancar et al.	2020	Hospitalized renal impairment	Comparative evaluation	Adults with impaired renal function	Renal labs	Clinical pharmacist-led dose adjustment approach

Inpatient Warfarin Management

Three studies supported pharmacist-driven warfarin management in hospital-linked contexts. In a pilot inpatient protocol, pharmacist management was described as an effective approach for ensuring adherence to evidence-based warfarin practices (Damaske et al. 2005). A larger quality initiative reported improved INR control after implementing a pharmacist-managed warfarin protocol; pharmacists monitored interactions and clinical status changes, aligning dosing with protocolized guidance (Daniels et al. 2018). A broader pharmacist-led anticoagulation model also showed improved control metrics in comparative settings (Alghadeeer et al. 2020). Together, these studies suggest that structured inpatient anticoagulation workflows benefit from pharmacist ownership of lab-linked decisions, with nurses supporting consistent administration, monitoring, and escalation of bleeding signals.

Vancomycin TDM and Antimicrobial Laboratory Workflows

Three studies focused on pharmacist-led TDM processes, often with explicit laboratory ordering or stewardship-like roles. A pharmacist-managed vancomycin TDM program in a tertiary hospital improved the likelihood of appropriate sample collection and dose adjustment by integrating pharmacists into ordering and interpreting pathology requirements (Firman et al. 2022). Another single-institution experience indicated that pharmacist-managed dose adjustment feedback using vancomycin TDM was clinically useful for MRSA-treated patients (Hirano et al. 2016). In pediatrics, pharmacist-directed TDM services optimized correct prescribing of initial doses and adjustments for vancomycin and other monitored agents (Hussain et al. 2021). In these studies, the nurse–pharmacist interface is most visible in timing and accuracy of sampling, prompt communication of results, and adherence to revised dosing plans. While these studies did not always quantify interprofessional behaviors, the success of TDM programs

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implicitly depends on reliable nursing execution of sampling windows aligned with pharmacokinetic plans.

Anti-Xa–Guided Prophylaxis in High-Risk Patients

In trauma and SICU populations, pharmacist recommendations for enoxaparin monitoring were frequently accepted, and dose adjustments following pharmacist input improved attainment of target anti-Xa ranges (Scrimenti et al. 2019). This suggests a practical safety mechanism where pharmacists interpret anti-Xa trends and recommend dose changes, while nurses ensure correct administration timing and facilitate repeat monitoring.

Renal Dose Adjustment and Laboratory-Informed Verification

Three studies evaluated pharmacist contributions to renal dosing safety. A hospital policy evaluation demonstrated pharmacist use and compliance with renal dose adjustment policies at order verification and discharge, highlighting the role of systematic lab-linked checks (Bassett et al. 2020). A quasi-experimental program in a tertiary hospital setting in Saudi Arabia evaluated renal drug dosing errors before and after implementing a pharmacist-led renal dosing initiative (Alqurashi et al. 2021). Another open-access study assessed clinical pharmacist-led dose adjustments in hospitalized patients with impaired renal function, underscoring the added value of expert review beyond reference tools alone (Sancar et al. 2020).

DISCUSSION

This review synthesizes open-access hospital evidence indicating that laboratory-guided medication safety improves when pharmacists are structurally integrated into protocols that depend on accurate, timely laboratory interpretation. The nine included original studies support the value of pharmacist-managed or pharmacist-driven models in inpatient warfarin management, antimicrobial TDM, anti-Xa monitoring in trauma populations, and renal dose adjustment processes.

From a systems perspective, these findings align with broader evidence that preventable medication harm is common and is responsive to structured safety interventions (Hodkinson et al. 2020). Pharmacist-led protocols appear to reduce variability in dosing decisions by aligning therapy with standardized lab thresholds and algorithm-informed actions. This is most clearly demonstrated in warfarin protocols, where improved INR control and reduced near-term safety signals were reported after shifting dosing responsibility to inpatient pharmacists supported by structured tools (Damaske et al. 2005; Daniels et al. 2018).

The antimicrobial domain reinforces the importance of laboratory accuracy and sampling logistics. The vancomycin TDM literature in this review suggests that pharmacists improve the likelihood of appropriate sample collection and dose adjustment when they are empowered to order and interpret relevant laboratory tests (Firman et al. 2022; Hirano et al. 2016; Hussain et al. 2021). These findings are consistent with higher-level evidence that vancomycin TDM improves clinical outcomes and reduces nephrotoxicity (Ye et al. 2013). Renal dose adjustment studies highlight another category of lab-dependent risk.

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Inappropriate dosing in renal impairment is a frequent and clinically consequential error type; pharmacist-led verification and structured renal dosing programs offer a scalable approach to mitigate this risk (Bassett et al. 2020; Alqurashi et al. 2021; Sancar et al. 2020).

Although the included studies often emphasize pharmacist outcomes, nurse roles are inseparable from laboratory-guided safety success. Nursing responsibilities in medication processes include coordinating correct sampling timing, recognizing clinical deterioration, and communicating contextual signals that alter pharmacokinetic interpretation (De Baetselier et al. 2021). Evidence mapping further suggests that nurse–pharmacist collaboration can improve medication safety in care transitions and settings (Ravi et al. 2022). Limitations of this review include heterogeneity in outcome reporting and the frequent absence of explicit metrics quantifying the collaborative behaviors themselves, despite their implied necessity. Future research should adopt standardized indicators of interprofessional laboratory workflow performance, including time-to-result action, sampling-window adherence, and nurse–pharmacist communication quality.

CONCLUSION

Hospital medication safety for high-alert and pharmacokinetically complex drugs depends on reliable laboratory-guided decision-making. The evidence synthesized here suggests that pharmacist-led protocols and lab-integrated pharmacy services improve monitoring appropriateness and dosing optimization in warfarin management, vancomycin TDM, anti-Xa–guided prophylaxis, and renal dose adjustment. These benefits are most likely maximized when nurses and pharmacists operate within shared, protocolized workflows that clarify responsibilities for sampling, result interpretation, dose adjustment, and follow-up monitoring. Hospitals should consider formalizing pharmacist–nurse collaborative pathways embedded directly into laboratory-triggered medication safety systems.

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