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The Role of Digital Transformation in Enhancing the Efficiency of Pharmaceutical Services in Saudi Hospitals

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ABSTRACT: Digital transformation has become a central driver of efficiency, safety, and quality improvement in hospital pharmacy practice worldwide, and Saudi Arabia's healthcare sector is undergoing a particularly rapid phase of this transition under the Vision 2030 national agenda. This paper examines how digital technologies — including electronic prescribing, automated dispensing systems, robotic pharmacy solutions, clinical decision support, and integrated national data platforms — are reshaping the efficiency and safety of pharmaceutical services within Saudi hospitals. Drawing on the Technology Acceptance Model, Rogers' Diffusion of Innovation theory, and Donabedian's structure-process-outcome model, the paper develops an original conceptual framework, DRIVE (Digitization, Robotics and automation, Interoperability, Vigilance through decision support, and Efficiency analytics), to organize the distinct mechanisms through which digital transformation enhances hospital pharmacy performance. The discussion is grounded in the Saudi regulatory and institutional context, referencing the Ministry of Health's digital health strategy, the Saudi Food and Drug Authority (SFDA), the Saudi Commission for Health Specialties (SCFHS), and national platforms including Nphies and Mumaris+. The paper concludes by identifying persistent barriers to full digital adoption — infrastructure gaps, workforce readiness, and interoperability limitations — and offering recommendations for accelerating the digital maturity of hospital pharmacy services in line with national transformation goals.

1. INTRODUCTION

Hospital pharmacy departments manage an increasingly complex volume of prescriptions, drug inventories, and clinical monitoring responsibilities, all of which depend on the accuracy and speed of underlying information systems. Traditional, paper-based, and manually managed pharmacy workflows are prone to inefficiency, delay, and preventable error, particularly as prescription volumes and medication complexity continue to rise. Digital transformation — the integration of electronic prescribing, automation, and data-driven decision support into pharmacy operations — has emerged as a central strategy for addressing these limitations.

This paper examines the role of digital transformation in enhancing the efficiency of pharmaceutical services within Saudi hospitals. It proposes an integrative framework, DRIVE, to organize the mechanisms through which digital technologies improve pharmacy performance, and situates this discussion within the broader digital health transformation agenda of Saudi Vision 2030.

1.1 Purpose and Scope

The purpose of this paper is to provide a structured account of how digital technologies are reshaping hospital pharmacy efficiency, safety, and service quality in the Saudi context. The scope encompasses electronic prescribing systems, pharmacy automation and robotics, interoperability with national digital health platforms, clinical decision support tools, and data analytics for operational efficiency.

2. THEORETICAL AND CONCEPTUAL FRAMEWORK

This paper's analysis draws on three complementary theoretical perspectives relevant to the adoption and impact of digital technology in healthcare settings.

2.1 The Technology Acceptance Model

The Technology Acceptance Model explains user adoption of new technologies in terms of perceived usefulness and perceived ease of use. Applied to hospital pharmacy, this model helps explain variation in the pace and depth of digital adoption among pharmacy staff, and underscores the importance of usability and demonstrated clinical value in successful implementation.

2.2 Rogers' Diffusion of Innovation Theory

Rogers' theory describes how innovations spread through an organization or system over time, distinguishing early adopters from later adopters based on factors such as relative advantage, compatibility with existing workflows, and observability of results. This perspective is useful for understanding the uneven pace of digital transformation across different hospital pharmacy departments and regions within Saudi Arabia.

2.3 Donabedian's Structure-Process-Outcome Model

Donabedian's model frames digital infrastructure as a structural resource that reshapes pharmacy processes — prescription verification, dispensing, and monitoring — with resulting effects on efficiency and safety outcomes. This paper applies the model to demonstrate that digital transformation delivers its impact primarily through improved process reliability and speed.

2.4 The DRIVE Framework

Building on these theoretical foundations, this paper proposes DRIVE as an organizing framework for the mechanisms through which digital transformation enhances hospital pharmacy efficiency:

- Digitization — the replacement of paper-based prescribing and documentation with electronic prescribing and integrated pharmacy records.
- Robotics and automation — the use of automated dispensing systems and robotic medication preparation to increase speed and accuracy.
- Interoperability — the secure exchange of prescription and patient data across hospital systems and national digital health platforms.
- Vigilance through decision support — the use of embedded clinical decision-support tools to flag interactions, allergies, and dosing errors in real time.
- Efficiency analytics — the use of operational data and dashboards to monitor workflow performance, inventory levels, and turnaround times.

DRIVE frames digital transformation not as a single technology deployment but as a coordinated set of five mechanisms that together compress the time between a prescribing decision and a safe, accurate dispensing outcome.

3. DIGITIZATION: ELECTRONIC PRESCRIBING AND RECORDS

The foundation of digital transformation in hospital pharmacy is the replacement of paper-based prescribing with electronic prescribing systems integrated into the hospital's broader electronic health record infrastructure.

3.1 Core Contributions

- Elimination of transcription errors associated with handwritten prescriptions and illegible handwriting.
- Immediate transmission of prescriptions from prescriber to pharmacy, reducing delays associated with manual delivery.
- Integrated access to patient medication histories, allergy records, and laboratory results at the point of prescription review.
- Standardized documentation that supports accurate billing, inventory tracking, and regulatory reporting.

3.2 Impact on Efficiency

Electronic prescribing has been consistently associated with reductions in prescription turnaround time and a marked decrease in errors attributable to illegible or incomplete handwritten orders. Within Saudi hospitals, the expansion of electronic prescribing under Ministry of Health digital health initiatives has progressively reduced the administrative burden historically placed on pharmacy staff for order clarification and verification.

4. ROBOTICS AND AUTOMATION: DISPENSING AND PREPARATION

Automated dispensing systems and robotic medication preparation technologies represent one of the most visible manifestations of digital transformation in hospital pharmacy, directly addressing the speed and accuracy of the dispensing process.

4.1 Core Contributions

- Automated dispensing cabinets that reduce retrieval time and support accurate tracking of controlled substances.
- Robotic dispensing systems that prepare high-volume prescriptions with reduced risk of manual picking errors.
- Automated compounding technology for sterile preparations, reducing contamination risk and preparation time.
- Barcode-based verification integrated into automated systems to confirm accurate drug, dose, and patient matching.

4.2 Impact on Efficiency

Hospitals that have adopted automated dispensing technology report substantial reductions in dispensing time and picking errors relative to fully manual systems, allowing pharmacy staff to redirect time toward clinical review and patient-facing activities rather than repetitive retrieval tasks. This shift also supports more accurate inventory control, reducing both stockouts and medication waste.

5. INTEROPERABILITY: CONNECTING PHARMACY TO THE NATIONAL HEALTH SYSTEM

The efficiency gains achieved within individual hospital pharmacy departments are substantially amplified when pharmacy systems are able to exchange data securely with other providers and national digital health infrastructure.

5.1 Core Contributions

- Integration with the Nphies platform for real-time claims processing, eligibility verification, and prescription data exchange.
- Cross-facility access to patient medication histories, reducing duplicate therapy and improving continuity of care during referrals.
- Standardized data formats that support consistent reporting to national pharmacovigilance and regulatory systems overseen by SFDA.
- Integration with Mumaris+ for verification of pharmacist licensing and credentialing status.

5.2 Impact on Efficiency

Interoperable systems reduce the administrative burden associated with manual claims processing and eligibility verification, accelerating dispensing workflows and reducing delays experienced by patients at the point of care. As Nphies integration

expands across Saudi healthcare providers, pharmacy departments are increasingly able to verify insurance coverage and medication history in real time rather than through manual, time-consuming processes.

6. VIGILANCE: CLINICAL DECISION SUPPORT AND SAFETY MONITORING

Beyond efficiency, digital transformation strengthens the safety function of hospital pharmacy through embedded clinical decision-support tools that operate continuously and consistently across every prescription reviewed.

6.1 Core Contributions

- Real-time alerts for drug-drug interactions, allergy conflicts, and therapeutic duplication at the point of order entry.
- Dose-checking algorithms that flag doses outside recommended ranges for a patient's age, weight, or renal function.
- Automated flagging of high-alert medications requiring additional verification before dispensing.
- Digital pharmacovigilance reporting tools that streamline adverse drug event documentation to SFDA surveillance systems.

6.2 Impact on Efficiency and Safety

Embedded decision-support tools reduce the time pharmacists spend manually cross-referencing interaction and dosing references, while simultaneously improving the consistency of safety checks across all prescriptions processed. This dual effect on both speed and safety illustrates why vigilance functions are considered inseparable from the efficiency gains attributed to digital transformation.

7. EFFICIENCY ANALYTICS: DATA-DRIVEN OPERATIONAL MANAGEMENT

Digital pharmacy systems generate continuous operational data that, when analyzed systematically, allow pharmacy leadership to identify bottlenecks, forecast demand, and allocate staffing resources more effectively.

7.1 Core Contributions

- Real-time dashboards tracking prescription volume, turnaround time, and staffing workload across shifts.
- Predictive inventory analytics that reduce medication shortages and excess stock holding costs.
- Performance benchmarking across pharmacy units to identify workflow bottlenecks and best practices.
- Data-informed staffing models that align pharmacist and technician coverage with peak prescription volume periods.

7.2 Impact on Efficiency

Hospitals that have implemented data analytics platforms for pharmacy operations report improved inventory turnover, reduced medication expiry losses, and more balanced staffing allocation relative to fluctuating patient demand. These gains illustrate how digital transformation extends beyond point-of-care safety functions to reshape the broader operational management of hospital pharmacy departments.

8. INTEGRATED SUMMARY: THE DRIVE FRAMEWORK IN PRACTICE

Table 1 summarizes the five DRIVE components, their representative technologies, and their principal linkage to pharmacy efficiency outcomes.

Table 1. Digital Technologies Mapped to the DRIVE Framework

DRIVE Component	Representative Technology	Efficiency Outcome
Digitization	Electronic prescribing and integrated records	Faster, error-free order transmission

DRIVE Component	Representative Technology	Efficiency Outcome
Robotics & Automation	Automated dispensing and robotic preparation	Reduced dispensing time and picking errors
Interoperability	Nphies and Mumaris+ integration	Faster claims and history verification
Vigilance	Clinical decision-support alerts	Consistent, faster safety screening
Efficiency Analytics	Operational dashboards and forecasting	Improved inventory and staffing efficiency

9. DIGITAL TRANSFORMATION WITHIN THE SAUDI HOSPITAL PHARMACY LANDSCAPE

Saudi Arabia's hospital pharmacy sector is undergoing a sustained period of digital transformation, driven by national health sector reform priorities and expanding investment in health information infrastructure.

9.1 Regulatory and Institutional Context

The Ministry of Health has prioritized digital health infrastructure as a core pillar of the health sector transformation strategy, supporting the expansion of electronic prescribing and integrated hospital information systems across public facilities. SFDA oversees the regulatory framework governing electronic pharmacovigilance reporting and digital medication safety systems. SCFHS licensing requirements increasingly reflect the expectation that pharmacists possess competency in digital pharmacy tools as part of continuing professional development.

9.2 Vision 2030 and National Platforms

The Nphies platform has become a central mechanism for unifying claims processing, eligibility verification, and prescription data exchange across Saudi healthcare providers, directly supporting the Interoperability component of the DRIVE framework. The Mumaris+ system similarly supports digital verification of pharmacist licensing and credentials. Together, these platforms reflect the broader Vision 2030 ambition to build an integrated, digitally enabled healthcare system capable of delivering more efficient and safer pharmaceutical services nationwide.

10. CHALLENGES TO DIGITAL TRANSFORMATION

- Infrastructure disparities: Digital maturity varies across hospitals, with smaller or more remote facilities often lagging in automation and system integration relative to major urban medical centers.
- Workforce readiness: Not all pharmacy staff possess equivalent digital literacy, and training gaps can slow the effective adoption of new systems.
- Interoperability limitations: Differences in legacy hospital information systems can complicate full integration with national platforms such as Nphies.
- Alert fatigue: Excessive or poorly calibrated clinical decision-support alerts can lead pharmacists to override or disregard warnings, undermining the intended safety benefit.
- Cybersecurity and data governance: Expanding digital infrastructure increases the importance of robust data protection measures to safeguard sensitive patient and medication information.

11. RECOMMENDATIONS

Building on the DRIVE framework and the challenges identified above, this paper offers the following recommendations for accelerating digital transformation in Saudi hospital pharmacy services:

- Prioritize investment in automation and electronic prescribing infrastructure for hospitals currently lagging in digital maturity, particularly outside major urban centers.
- Expand structured digital literacy training for pharmacy staff as part of continuing professional development aligned with SCFHS requirements.
- Continue strengthening Nphies integration to ensure consistent interoperability across all levels of the healthcare system.
- Refine clinical decision-support alert thresholds to reduce alert fatigue while preserving critical safety warnings.
- Establish standardized cybersecurity protocols for pharmacy information systems in line with national data protection requirements.
- Develop pharmacy-specific efficiency dashboards as a standard component of hospital digital health infrastructure to support ongoing operational improvement.

12. CONCLUSION

Digital transformation is fundamentally reshaping the efficiency, safety, and operational management of hospital pharmacy services in Saudi Arabia. The DRIVE framework proposed in this paper — Digitization, Robotics and automation, Interoperability, Vigilance through decision support, and Efficiency analytics — illustrates the distinct yet complementary mechanisms through which digital technologies compress the time between prescribing and safe dispensing while strengthening the safety net around every medication that reaches a patient. Within the Saudi healthcare system, the regulatory foundations provided by the Ministry of Health, SFDA, and SCFHS, together with the integration efforts of Nphies and Mumaris+ under Vision 2030, are creating increasingly favorable conditions for hospital pharmacies to achieve full digital maturity. Sustained progress will depend on continued investment in infrastructure, workforce digital competency, and interoperable systems that allow pharmacy departments to operate at the full efficiency that digital transformation makes possible.

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