

Exploring the Impact of Technology on Medication Management: A Mixed-Methods Study in a Tertiary Care Hospital

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Abstract

Background: Medication errors pose significant challenges in healthcare, particularly in tertiary hospitals. Health information technology (HIT) offers solutions to improve medication management, enhance patient safety, and optimize workflows.

Objective: This study evaluates the impact of HIT on medication management using a mixed-methods approach.

Methods: Quantitative data were collected through pre- and post-implementation comparisons of medication errors, adverse drug events (ADEs), and workflow efficiency. Qualitative data included interviews and focus groups with healthcare providers and patients to explore their experiences with HIT.

Results: Medication errors decreased by 55%, ADEs by 57%, and hospital readmissions by 33%. Workflow efficiency improved, with task completion times reduced by 33–40%. Qualitative findings revealed improved patient safety, streamlined workflows, and increased provider satisfaction. Challenges included usability issues and initial resistance to change.

Conclusion: HIT significantly enhances medication safety, efficiency, and user satisfaction in tertiary hospitals. Addressing usability and implementation barriers is critical for maximizing its potential.

Keywords: Health Information Technology, Medication Management, Tertiary Care Hospital, Patient Safety, Workflow Efficiency, Mixed-Methods Study

Introduction

Medication errors are regarded as a cardinal issue in the delivery of health services, especially in tertiary care hospitals which have intricate medication prescriptions and high patient load. Studies have suggested that there are recurring errors in medication administration which endangers the safety of the patients and the overall clinical outcome (Keers et al., 2014). The introduction of health information technology (HIT) has been seen as one of the approaches to minimizing errors as well as for the improvement of the safety and efficacy of medication management systems (Appari et al., 2012).

Closed-loop electronic medication management systems (EMMS), bar-code medication administration (BCMA), and electronic prescribing (e-prescribing) are some technologies that are being adopted in the hospital setting. These devices are meant to improve medication workflow processes, documentation, and reduce errors attributable to a healthcare provider (Austin et al., 2018). For instance, EMMS are said to have the ability to cut medication turnaround times when compared to traditional paper-bound systems, which is indeed a huge advantage (Westbrook et al., 2013).

In addition, systematic reviews prove that certain technologies such as BCMA, when combined with computerized prescriber order entry (CPOE), makes a closed-loop system that significantly reduces risk of preventable medication errors (Shah et al., 2016). Overcoming user resistance, integration into current electronic health record systems, and expenses are still some of the issues that hinder the adoption of these technologies (McKibbin et al., 2012).

The objective of the study is to evaluate how the adoption of technology affects medication management in a tertiary care hospital. Using a mixed-methods approach, the study seeks to quantitatively evaluate medication safety and efficiency improvements alongside qualitatively understanding the healthcare providers' experiences and perceptions. It is critical to examine these issues in order to improve technology adoption in health care and its effective use in clinical practice.

Literature Review

Like other aspects of health information technology, medication management has received a lot of attention in healthcare systems, especially in tertiary hospitals. Medication management consists of prescribing, dispensing, administering, and monitoring medication. HIT methods such as EMMS are purported to enhance safety and efficacy during these stages (McKibbin et al., 2011).

In effect economic appraisals of HIT are cost effective in case of medication management because of cost savings through lowered adverse drug events and improved efficiency in hospitals (O'Reilly et al., 2012). For example, the construction of regionally shared medication lists has proven to be beneficial in enhancing care continuity and improving physician's out-of-office judgments. However, there are also some barriers such as absence of interoperability between the system and user acceptance.

Tele monitoring, artificial intelligence, and automated medicine dispensing systems are some of the new technologies enabling new approaches in medication management. These technologies are designed for better user compliance, lower error rates, and increased personalization (Eggerth et al., 2020). As these technologies advance, it is believed that smart medication management systems can mitigate concerns around the safety of patients because of their monitoring capabilities and decision support in real time (Rokni&Ghasemzadeh, 2017).

Like ReX system, other medication management devices that resolve issues of adherence to medications by patients and alleviating other related complications have been developed. However, those systems should enable accurate tracking of individual dosages dispensed per an approved case so that misuse could be avoided (Shtrichman et al., 2018).

Meum (2012) identified the socio-technical components of implementing EMMS and found issues with workflow integration that requires more thought concerning the clinician's workflows as well as team dynamics. Teamwork through collaborative practices, such as nurse-led technology-assisted medication management, is an effective way to utilize technology for medication management (Yang et al., 2022).

To conclude, even though information health technologies can greatly improve the practices of medication management, their adoption is carved out by technical, financial, and socio-cultural factors that determines their effective utilization towards increasing the safety of patients and efficiency of the healthcare system. This is an area of ongoing investigation building on current literature on such technologies in tertiary hospitals.

Methodology

Study Design

This mixed-methods study was conducted in a tertiary care hospital to evaluate the impact of health information technology (HIT) on medication management. The study incorporated both quantitative and qualitative approaches to provide a comprehensive analysis of technology's role in improving medication safety, efficiency, and user experience.

Study Setting

The research was conducted at a tertiary care facility, serving a diverse patient population. The hospital had implemented various HIT systems, including electronic medication management systems (EMMS), bar-code medication administration (BCMA), and computerized prescriber order entry (CPOE).

Study Population

The study included:

-Healthcare Providers: Physicians, nurses, and pharmacists involved in medication management workflows.

-Patients: Adult inpatients prescribed medications during their hospital stay.

Participants were recruited using stratified random sampling to ensure diverse representation across departments.

Quantitative Data Collection

1. Pre- and Post-Implementation Analysis: Medication error rates were measured six months before and after the implementation of HIT systems. Data was collected from the hospital's incident reporting system.

2. Time and Motion Study: Observations were conducted to assess the time taken for critical medication management tasks (e.g., prescribing, dispensing, and administration) before and after HIT adoption.

3. Patient Outcomes: Data on adverse drug events (ADEs) and hospital readmission rates were collected to evaluate clinical outcomes.

4. Staff Satisfaction Survey: A validated Likert-scale questionnaire was administered to healthcare providers to measure satisfaction with HIT systems.

Qualitative Data Collection

1.Semi-Structured Interviews: In-depth interviews were conducted with 20 healthcare providers, including physicians, nurses, and pharmacists. The interviews explored experiences, perceived benefits, and challenges associated with HIT use in medication management.

2.Focus Groups: Two focus groups with 8 participants each (one with clinicians, one with patients) were conducted to gain insights into barriers to HIT adoption and suggestions for improvement.

3.Document Analysis: Hospital policies, training manuals, and HIT implementation strategies were reviewed to contextualize findings.

Data Analysis

1.Quantitative Analysis:

- Descriptive statistics were used to summarize medication error rates, task times, and survey responses.

- Paired t-tests and chi-square tests were performed to compare pre- and post-implementation data.

- Regression analysis was conducted to evaluate the relationship between HIT use and patient outcomes.

2.Qualitative Analysis:

- Interviews and focus group discussions were audio-recorded, transcribed, and analyzed thematically using NVivo software.

- Themes were identified based on a combination of inductive coding and predefined categories e.g., usability, efficiency, patient safety).

Ethical Considerations

Ethical approval was obtained from the ethics committee. Written informed consent was obtained from all participants before data collection. Confidentiality and anonymity were maintained throughout the study.

Findings

Quantitative Findings

1.Medication Errors and Patient Outcomes

The implementation of health information technology (HIT) significantly reduced medication errors, adverse drug events (ADEs), and hospital readmissions. The following table summarizes these findings:

Phase	Medication Errors (per 1000 prescriptions)	Adverse Drug Events (ADEs)	Hospital Readmissions (per 100 patients)
Pre-Implementation	45	35	18
Post-Implementation	20	15	12

2.Time and Motion Study

A time and motion study was conducted to evaluate the efficiency of medication-related tasks (prescribing, dispensing, and administration). HIT adoption led to a substantial reduction in time spent on these tasks, as shown below:

Task	Pre-Implementation (minutes)	Post-Implementation (minutes)	Time Saved (%)
Prescribing	12	8	33.33
Dispensing	15	10	33.33
Administration	20	12	40.00

3. Staff Satisfaction Survey

A Likert-scale survey was conducted to assess healthcare providers' satisfaction with HIT. The mean ratings improved significantly post-implementation across categories such as ease of use, workflow integration, and perceived patient safety improvements:

Category	Mean Pre-Implementation Rating (1-5)	Mean Post-Implementation Rating (1-5)	Improvement (%)
Ease of Use	2.8	4.2	50.00
Workflow Integration	3.0	4.5	50.00
Patient Safety Improvement	2.9	4.6	58.62

Qualitative Findings

The qualitative findings were analyzed thematically, revealing key themes and sub-themes based on the responses from healthcare providers and patients. Below is a detailed summary with illustrative participant replies.

Theme 1: Improved Patient Safety

-Sub-theme 1.1: Reduction in Medication Errors

- Most respondents for this study noted reduction in frequency of prescribing and administering errors due to the HIT systems in place.

- Participant Response:

- “The shift to the computerized prescribing model has markedly improved the frequency of prescribing errors from indecipherable handwritings.” (Pharmacist, Participant 4)

- Participant Response:

- “The introduction of the system has reduced the amount of nurse shift administration errors made during busy work shifts.” (Nurse, Participant 7)

-Sub-theme 1.2: Enhanced Monitoring of Adverse Drug Events (ADEs)

- The system’s capability to identify high-risk drugs and interactions was flagged as a key strength.

- Participant Responses:

- “Drug-drug interactions alerts have assisted us in identifying and mitigating some potential ADEs.” (Physician, Participant 12)

Theme 2: Workflow Efficiency

-Sub-theme 2.1: Streamlining Processes

- “HIT Enabled faster workflows which minimized the duration taken for medication prescribing, dispensing and administration.”

- Participant Statement:

- “The EMMS has reduced the time scanning for patient records and prescriptions, particularly at the time of emergencies.” Pharmacist, Participant 6)

- Participant Statement:

- “Automated alert and reminders facilitated enhanced task prioritization aiding in faster overall task completion.” Nurse, Participant 3)

-Sub-theme 2.2: Reduced Workload

-Respondents stated that automation in processes lessened workload on administration.

- Participant Remarks:

- "My colleagues and I have more time to spend on patient care since our automated system do daily checks on medications which are one of the most resource consuming parts of the job." (Nurse, Participant 9)

Theme 3: Challenges in Technology Adoption

-Sub-theme 3.1: Usability Issues

- A number of users experienced difficulties in operating the HIT systems as they found them to be rather unhelpful during the implementation period.

- “It took us a while to get used to the interface; training could have been more comprehensive,” a physician participant, 8, said.

- “Too many clicks to execute certain operations can be annoying during activity peaks.” a nurse participant, 2, said.

-Sub-theme 3.2: Resistance to Change

- It was reported that staff adoption of the new system posed some resistance which acted as a barrier.

- Participant Response:

- “At first, many of my coworkers were hesitant to utilize the system because it was assumed to be a hindrance.” (Pharmacist. Participant 10)

Theme 4: Perceived Benefits of Patient Engagement

-Sub-theme 4.1: Improved Communication

- The improvement of communication and comprehension regarding their medications, as a result of HIT, was well received by patients.

- Respondent Comments

“... The pharmacist clarified the alerts on the system to me, and it made me understand why my medications were changed.” (Patient, Participant 15)

-Sub-theme 4.2: Increased Trust in Care

- Understanding that doctors are supervised assuaged patient worries.

- Participant Quote:

- “It feels good to know that there is system that ensures everything is done correctly in relation to my care.” Patient, Participant 18)

Discussion

This study’s findings show that the use of health information technology (HIT) greatly enhances the medication management processes within a tertiary care hospital. This discussion seeks to elaborate on the findings through juxtaposed qualitative and quantitative data, the implications of the findings, challenges that are currently being faced, and provide reasonable suggestions for improvements.

Impact on Medication Safety

The analysis revealed that the implemented HIT systems significantly decreased the number of medication-related mistakes errors, adverse drug events (ADEs), and hospital readmissions. This is in line with previous studies that highlight the impact of the electronic prescribing systems, bar-code medication administration (BCMA), and closed-loop medication management systems on human error mitigation (McKibbon et al., 2011; Shah et al., 2016). The healthcare professionals who provided qualitative feedback also confirmed these improvements stating that system automated alerts and checks eliminated errors that would ordinarily go undetected during manual processes.

Enhancements in Workflow Efficiency

The adoption of HIT resulted in the reduction of the time needed for prescribing, dispensing, and administering medications by 33% to 40%. These observations corroborate earlier studies that have shown how the use of technology leads to better management of clinical activities and lower administrative work (Westbrook et al., 2013). People reported that automatically generated processes provided them more opportunity to engage in patient-centered care. Nonetheless, as noted, some complexities like complicated screens posed as obstructions to efficiency during the roll out phase.

Staff Satisfaction and Adoption

The staff satisfaction survey showed gradual ease of use, workflow incorporation, and patient safety metrics perception improvement post implementation. This suggests that after the initial aversion to modifying processes, the providers appreciated the role of HIT in improving patient care. Change

aversion is well-documented in HIT literature and usually arises from insufficient training and fear of disturbing existing routines (Meum, 2012). These concerns can be allayed through comprehensive training and continuous assistance leading to greater acceptance.

Challenges and Barriers

The study details the positive aspects of HIT but points out the main challenges, which include high costs, usability issues, and resistance to change. Study participants noted feeling annoyed with having to cope with complications in the user interface and spending excessive time on mundane tasks, as pointed out in previous studies as well (Hammar, 2014). Furthermore, some qualitative data indicated that skepticism toward HIT among some health professionals in the early phases stemmed from worries that it would be an added burden to their current workloads. These obstacles highlight the requirement for a refinement of system design and feedback integration in order to enhance usability.

Patient-Centered Benefits

The research additionally showed that clients considered the HIT systems to enhance trust and communication during their care as well. Patients' engagement and adherence to therapy was improved due to automated alerts and explanations given by pharmacists. This is in accordance with research regarding the contribution of HIT to patient participation in shared clinical decisions and compliance with prescribed medications (Shtrichman et al., 2018).

Implications for Practice

The conclusions drawn from this research are pertinent to practice at tertiary care hospitals:

1. **Training and Support:** Continuous training sessions should be put in place to resolve the usability concerns and improve the staff's competency in utilizing HIT systems.
2. **Iterative System Improvements:** Active end-users have a propensity to improve system design and use, and therefore participation in the design and development stage should be solicited.
3. **Comprehensive Implementation Strategies:** A gradual proposed implementation with proactive and supportive communication will aid in the resistance to change.
4. **Patient Engagement:** HIT systems should be utilized to supplement patient education on appropriate medication self-management.

Limitations and Future Directions

This study was conducted in a single tertiary hospital which could be a limitation as the data may not be generalizable. Moreover, it only evaluated short-term outcomes, leaving the long-term benefits of the adoption of HIT unaddressed. Future studies should incorporate multi-center designs. Furthermore, economic evaluations for the long-term use of HIT should also be conducted.

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