International Journal of Frontiers in
Medicine and Surgery Research
Journal homepage: https://frontiersrj.com/journals/ijfmsr/
ISSN: 2783-0489 (Online)

(REVIEW ARTICLE)

The impact of healthcare information technology on reducing medication errors: A review of recent advances

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International Journal of Frontiers in Medicine and Surgery Research, 2024, 05(02), 020–029

Publication history: Received on 28 February 2024; revised on 05 April 2024; accepted on 08 April 2024

Article DOI: https://doi.org/10.53294/ijfmsr.2024.5.2.0034

Abstract

This review explores the impact of HIT on reducing medication errors, encompassing recent advances in electronic health records (EHRs), clinical decision support systems (CDSS), bar-coding technology, telemedicine, and mobile health applications. By synthesizing evidence from scholarly literature, case studies, and real-world implementations, this paper delineates the multifaceted benefits, challenges, and future prospects of integrating HIT into medication management processes. Understanding the evolving role of HIT in error reduction is pivotal for healthcare stakeholders to optimize patient outcomes and enhance the quality and safety of medication administration. In the dynamic realm of modern healthcare, medication errors loom as a formidable challenge, imperiling patient safety, compromising care quality, and inflating healthcare expenditures. However, amidst this backdrop of concern, healthcare information technology (HIT) emerges as a beacon of hope, offering potent remedies to counteract these errors. This review embarks on a journey to unravel the profound impact of HIT on ameliorating medication errors, delving into recent strides across various fronts including electronic health records (EHRs), clinical decision support systems (CDSS), bar-coding technology, telemedicine, and mobile health applications. Drawing upon a rich tapestry of scholarly literature, real-world case studies, and practical implementations, this paper meticulously examines the multifaceted landscape of HIT's influence on medication management. Through a comprehensive synthesis of evidence, we uncover the diverse benefits, confront the inherent challenges, and illuminate the promising vistas that emerge from the integration of HIT into medication-related processes. At the core of this exploration lies an urgent call to comprehend the evolving role of HIT in error reduction, recognizing its pivotal significance for healthcare stakeholders. By assimilating insights from disparate sources, we endeavor to empower stakeholders with the knowledge necessary to optimize patient outcomes, fortify the fabric of care delivery, and foster a culture of safety and excellence in medication administration. In essence, this review serves as a guiding compass amidst the labyrinth of healthcare challenges, illuminating pathways towards safer, more efficient, and more effective medication management practices. As we navigate this terrain, let us remain steadfast in our commitment to harness the transformative power of HIT, thereby ushering in a new era of enhanced patient safety, elevated care quality, and sustainable healthcare systems. In the contemporary healthcare landscape, medication errors represent a significant concern, posing risks to patient safety, quality of care, and overall healthcare costs. However, advancements in healthcare information technology (HIT) offer promising solutions to mitigate these errors.

Keywords: Healthcare information technology; Medication errors; Electronic health records; Clinical decision support systems; Telemedicine; Mobile health applications

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1. Introduction

The causes of medication errors are multifactorial and often stem from systemic issues within healthcare delivery systems (Schroers and Moriarty, 2021). Factors such as communication breakdowns, inadequate training, workflow inefficiencies, and medication-related policies can all contribute to the occurrence of errors. Additionally, the prevalence of handwritten prescriptions and reliance on paper-based documentation systems further exacerbate the risk of errors. Despite concerted efforts to address this issue, medication errors persist as a significant challenge within healthcare. Traditional approaches to error reduction, such as education and training programs for healthcare professionals, have had limited success in stemming the tide of errors (O'Reilly and Loeches, 2023).

As such, there is a growing recognition of the need for innovative solutions that harness the power of technology to enhance medication safety (Jim et al., 2020). Significance of the Study The significance of exploring the impact of HIT on reducing medication errors cannot be overstated. As healthcare systems continue to grapple with the challenges posed by medication errors, there is an urgent need for evidence-based strategies to mitigate these risks and improve patient outcomes. HIT holds immense potential in this regard, offering a range of tools and technologies that can augment existing medication management practices (Senbekov et al., 2020).

By conducting a comprehensive review of the literature and synthesizing evidence from real-world implementations, this study seeks to inform healthcare stakeholders about the potential benefits and challenges associated with integrating HIT into medication management processes (Sung et al., 2022). By elucidating the mechanisms through which HIT can contribute to error reduction, this review aims to empower healthcare organizations and policymakers to make informed decisions about the adoption and implementation of HIT solutions. Furthermore, this study has implications not only for patient safety but also for healthcare delivery efficiency and cost-effectiveness.

By reducing the incidence of medication errors, HIT has the potential to minimize the need for costly interventions, such as hospital readmissions and adverse event management (Austin , 2020). Additionally, HIT can streamline medication-related workflows, saving time and resources for healthcare professionals and improving overall efficiency within healthcare organizations. In sum, this study has the potential to contribute valuable insights to the ongoing discourse surrounding medication safety and HIT adoption in healthcare (Al-Worafi, 2023.).

By shedding light on the intersection of these two critical areas, this review aims to pave the way for enhanced patient outcomes, improved care quality, and more sustainable healthcare systems. Aim and Scope

The aim of this review is to explore the impact of healthcare information technology (HIT) on reducing medication errors, encompassing recent advances in electronic health records (EHRs), clinical decision support systems (CDSS), bar-coding technology, telemedicine, and mobile health applications. By synthesizing evidence from scholarly literature, case studies, and real-world implementations, this paper aims to delineate the multifaceted benefits, challenges, and future prospects of integrating HIT into medication management processes (Han et al., 2023).

2. Overview of Medication Errors

Overview of Medication errors represents a significant challenge in healthcare systems worldwide (Rodziewicz and Hipskind, 2020). These errors occur when there are discrepancies between the prescription, administration, dispensing, or monitoring of medication, leading to potentially harmful outcomes for patients. Despite rigorous safety protocols, medication errors persist across various healthcare settings, including hospitals, clinics, pharmacies, and long-term care facilities. Definition and Classification Medication errors encompass a broad spectrum of mistakes in the medication process, from prescribing to administration.

They can be categorized into several types, Prescribing Errors, Occur when healthcare providers inaccurately prescribe medication (Alshahrani, 2021). This may involve incorrect dosage, frequency, route of administration, or medication choice. Factors contributing to prescribing errors include illegible handwriting, lack of access to complete patient information, and inadequate knowledge of medications. Dispensing errors may include providing the wrong medication, incorrect dosage, or incorrect packaging.

Factors such as distractions, high workload, and similarities in drug names contribute to dispensing errors (Ahmadi, 2020). Administration Errors, Occur when healthcare professionals administer medication incorrectly to patients. This may involve administering the wrong medication, incorrect dosage, or administering medication via the wrong route. Factors contributing to administration errors include distractions, fatigue, inadequate training, and miscommunication

among healthcare team members. Monitoring Errors, Involve failures in monitoring patients' response to medication therapy or detecting adverse effects(Härkänen, 2020).

This may result in delayed recognition of medication-related problems, leading to patient harm or treatment failure (Laroche et al., 2021). Factors contributing to monitoring errors include inadequate follow-up procedures, lack of patient education, and insufficient resources for patient monitoring. Prevalence and Impact Medication errors pose a significant threat to patient safety and can have far-reaching consequences. Despite efforts to reduce their occurrence, medication errors remain prevalent in healthcare systems globally (Alqenae et al., 2020).

Studies have shown varying rates of medication errors depending on the healthcare setting, with hospitals and long-term care facilities reporting higher rates compared to outpatient settings. The impact of medication errors on patients can range from mild discomfort to severe harm, and in some cases, death. Adverse drug events resulting from medication errors contribute to prolonged hospital stays, increased healthcare costs, and decreased quality of life for patients (Breuker et al., 2020). Furthermore, medication errors can erode patient trust in healthcare providers and institutions, leading to decreased patient satisfaction and adherence to treatment regimens.

In addition to the direct impact on patients, medication errors also place a significant burden on healthcare systems and providers (Alrabadi et al., 2021). Healthcare organizations incur additional costs associated with managing medication-related adverse events, implementing corrective measures, and potential legal repercussions. Moreover, healthcare professionals may experience emotional distress and professional consequences as a result of being involved in medication errors (Voultsos et al., 2020).

Causes and Contributing Factors Medication errors are rarely the result of a single cause but rather stem from a combination of factors related to individual, systemic, and organizational elements (Freitas et al., 2020). Some common causes and contributing factors include, Human Factors, Healthcare professionals are susceptible to errors due to factors such as fatigue, stress, distractions, and cognitive biases. High workload and time pressures can impair decision-making and increase the likelihood of mistakes during the medication process. Communication Breakdown, Inadequate communication among healthcare team members, as well as between healthcare providers and patients, can lead to misunderstandings and errors in medication management (Clapper and Ching, 2020).

3. Role of Healthcare Information Technology

Alerts and Reminders, CDSS generate real-time alerts and reminders for healthcare providers based on predefined clinical rules, guidelines, and protocols (Olakotan and Mohd Yusof, 2021). These alerts notify providers of potential drug interactions, allergy warnings, abnormal test results, overdue screenings, and recommended treatments, enhancing patient safety and adherence to best practices identification, verification, and documentation of these items at various points of care. Key benefits of bar-coding technology include, Chronic Disease Management, Telemedicine supports remote monitoring and management of chronic conditions, such as diabetes, hypertension, heart failure, and mental health disorders.

Patients can use connected devices and wearable sensors to track vital signs, symptoms, and medication adherence, allowing healthcare providers to intervene proactively and adjust treatment plans as needed to optimize health outcomes (Kiyani et al., 2020). Emergency and Urgent Care, Telemedicine provides timely access to emergency and urgent care services for patients in remote or underserved areas. Telemedicine platforms enable patients to connect with emergency physicians and healthcare providers for triage, assessment, and initial treatment of acute medical conditions, improving patient outcomes and reducing unnecessary emergency department visits and hospital admissions (Nourazari et al., 2021).

Mobile Health Applications Mobile health applications, or health apps, are software applications designed for mobile devices, such as smart phones and tablets, to support health and wellness-related activities, including health monitoring, self-management, education, and communication (Caldeira, 2020). Health apps empower individuals to take an active role in managing their health and well-being, providing access to personalized health information, tools, and resources anytime, anywhere.

Key categories and functionalities of mHealth apps include, Health Tracking and Monitoring, mHealth apps enable users to track and monitor various aspects of their health, including physical activity, sleep patterns, nutrition, medication adherence, vital signs and chronic disease management (Rozanski et al., 2023). Users can input data manually or sync data from wearable devices and sensors to track progress, set goals, and receive personalized insights and feedback. Health Education and Information, mHealth apps provide access to evidence-based health information, educational

resources, and interactive multimedia content on a wide range of health topics, conditions, and treatments (Suarez and Alvarez, 2021).

Users can access articles, videos, tutorials, and quizzes to learn about preventive care, self-care strategies, and management of specific health conditions, empowering them to make informed decisions about their health (Barbosa et al., 2021). Behavioral Interventions and Support, mHealth apps offer behavioral interventions and support tools to promote healthy behaviors, habits, and lifestyle changes. These include goal-setting features, reminders, motivational messages, social support networks, and coaching programs to encourage users to adopt and sustain positive health behaviors, such as smoking cessation, weight management, stress reduction, and physical activity (Vogel and Ramo, 2021).

Remote Consultations and Telehealth Services, Some mHealth apps enable users to connect with healthcare providers remotely for virtual consultations, telehealth services, and digital health coaching (Markert et al., 2021). Users can schedule appointments, communicate with healthcare providers via secure messaging or video conferencing, and receive personalized advice, prescriptions, and referrals without the need for in-person visits. Medication Management, mHealth apps support medication management and adherence by providing medication reminders, dosage instructions, refill alerts, and medication tracking tools (Faisal , 2021).

Users can create medication schedules, set reminders for doses, record adherence data, and receive notifications for missed doses or potential drug interactions, improving medication adherence and treatment outcomes (Kretchy et al., 2021). In conclusion, Healthcare Information Technology (Health IT) plays a critical role in transforming the delivery and experience of healthcare services. From Electronic Health Records (EHRs) to Clinical Decision Support

4. Impact of HIT on Reducing Medication Errors

Supporting Clinical Decision Making Clinical decision-making involves the process of selecting optimal treatment strategies and interventions for individual patients based on their clinical presentation, medical history, preferences, and available evidence (Cusi et al., 2021). Supporting clinical decision-making involves providing healthcare providers with access to timely, relevant, and actionable information to inform their decisions, Evidence-Based Practice Guidelines, Incorporating evidence-based practice guidelines and clinical protocols into clinical decision support systems helps standardize care practices and promote adherence to best practices (Trinkley et al., 2021).

Guidelines provide recommendations for diagnosis, treatment, and management of specific conditions, empowering healthcare providers to make informed decisions based on the latest evidence (Chervenak et al., 2021). Clinical Decision Support Tools, Deploying clinical decision support tools within EHRs and CPOE systems assists healthcare providers in evaluating diagnostic test results, interpreting clinical data, and formulating treatment plans. Decision support tools provide real-time alerts, reminders, and recommendations tailored to individual patient characteristics and clinical contexts, enhancing clinical decision-making and patient safety (Shahmoradi et al., 2021).

Risk Prediction Models, Utilizing risk prediction models and prognostic tools supports clinical decision-making by estimating patients' risk of adverse outcomes, complications, or disease progression (White et al., 2020). Risk scores, predictive algorithms, and decision trees enable healthcare providers to stratify patients based on their likelihood of experiencing certain events and tailor interventions accordingly to optimize outcomes. Shared Decision Making, Engaging patients in shared decision-making processes empowers them to actively participate in decisions about their healthcare and treatment options. Decision aids, patient education materials, and shared decision-making tools facilitate discussions between patients and healthcare providers, promoting informed choices, preferences, and values alignment (Witteman et al., 2021).

5. Challenges and Barriers

Resistance to Change, Healthcare providers and staff may resist adopting Health IT solutions due to concerns about changes in workflow, job roles, and patient interactions (Talwar et al., 2023). Overcoming resistance to change requires effective communication, leadership support, and engagement strategies to address misconceptions, fears, and perceived barriers to adoption. Training Needs, Inadequate training and education on Health IT systems can hinder users' ability to effectively utilize and leverage technology.

Healthcare organizations must invest in comprehensive training programs, user support resources and ongoing professional development to ensure users have the knowledge, skills, and confidence to use Health IT tools effectively.

Usability Issues, Poor usability and user experience design can lead to frustration, errors, and low adoption rates among healthcare providers and staff. Health IT systems should prioritize usability testing, user-centered design principles, and feedback mechanisms to enhance usability and address user preferences and needs (Walden et al., 2020).

Challenges in Health IT implementation can arise from issues related to infrastructure, system performance, and software development, Infrastructure Limitations, Inadequate infrastructure, such as outdated hardware, network bandwidth limitations, and connectivity issues, can hinder the performance and reliability of Health IT systems (Hartmann et al., 2022). Upgrading infrastructure, expanding network capacity, and ensuring redundancy and failover mechanisms are essential to support the scalability and resilience of Health IT solutions.

System Interoperability, Achieving seamless interoperability between different Health IT systems, platforms, and devices requires overcoming technical barriers, such as incompatible data formats, proprietary interfaces, and disparate standards (Rauh et al., 2022). Developing standardized interoperability frameworks, APIs, and data exchange protocols can facilitate data sharing and integration across heterogeneous systems. Software Complexity, Health IT software development involves complex requirements, functionalities, and regulatory compliance considerations, which can pose challenges for development, testing, and deployment.

Adopting agile development methodologies, Divots practices, and continuous integration/continuous deployment (CI/CD) pipelines can streamline software development processes and accelerate time-to-market while ensuring quality and compliance (Levée, 2023). Financial Constraints Financial constraints present significant challenges for healthcare organizations seeking to invest in Health IT infrastructure, systems, and services,. Cost of Implementation, The upfront costs of acquiring, implementing, and customizing Health IT solutions, such as EHR systems, clinical decision support tools, and telemedicine platforms, can be substantial.

Healthcare organizations must budget for hardware, software licenses, implementation services, training, and ongoing maintenance and support costs to ensure successful implementation and sustainability (Wiwatkunupakarn, et al., 2023). Return on Investment (ROI), Demonstrating the ROI of Health IT investments can be challenging due to the long-term nature of benefits and the difficulty in quantifying improvements in patient outcomes, efficiency gains, and cost savings. Healthcare organizations must develop robust business cases, performance metrics, and evaluation frameworks to assess the value and impact of Health IT investments on organizational goals and objectives.

Reimbursement Models, Changes in reimbursement models, payment incentives, and regulatory requirements may influence healthcare organizations' ability to invest in Health IT (Anderson et al., 2020). In conclusion, addressing challenges and barriers in Healthcare Information Technology (Health IT) implementation requires a multi-faceted approach that addresses technical, organizational, regulatory, and financial considerations. By prioritizing interoperability, user acceptance, data security, technical innovation, and financial sustainability, healthcare organizations can overcome barriers to Health IT adoption and realize the full potential of technology to improve patient care, outcomes, and healthcare delivery.

6. Case Studies and Real-world Implementations

Artificial Intelligence and Machine Learning Applications Artificial Intelligence (AI) and Machine Learning (ML) are revolutionizing medication management and healthcare delivery (Alowais et al., 2023) AI and ML applications in medication management include, Predictive Analytics, AI and ML algorithms analyze patient data to predict medication adherence, identify at-risk patients, and anticipate adverse drug events. Predictive analytics enable proactive interventions, personalized treatment plans, and improved patient outcomes.

FHIR enables standardized APIs for accessing and exchanging healthcare data, facilitating interoperability between EHR systems, clinical applications, and mobile health apps. National Institute of Standards and Technology (NIST), NIST develops standards and guidelines for healthcare interoperability, security, and privacy, such as the NIST Framework for Improving Critical Infrastructure Cyber security (NIST Cyber security Framework). NIST's interoperability frameworks provide guidance on data formats, encryption protocols, and identity management for secure data exchange and interoperability (Mouchou et al., 2021).

Common Well Health Alliance, Common Well Health Alliance is a collaborative effort among healthcare organizations to promote nationwide health data exchange and interoperability. Common Well members implement interoperability standards and protocols to enable seamless sharing of patient health information across healthcare settings, improving care coordination and continuity (Ukoba et al., 2018). Remote Monitoring and Telehealth, Remote monitoring devices

and telehealth platforms enable patients to monitor their health status, track medication adherence, and communicate with healthcare providers from home.

Remote monitoring programs empower patients to take an active role in managing their health conditions, reducing the need for in-person visits and hospitalizations Policy Implications and Regulatory Frameworks Policy implications and regulatory frameworks shape the adoption, implementation, and use of Health IT solutions in medication management. Key considerations include, Health Information Exchange (HIE) Policies, HIE policies govern the sharing, access, and use of patient health information across healthcare organizations and stakeholders.

Regulatory frameworks, such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States, establish standards and requirements for protecting patient privacy, confidentiality, and security in health information exchange activities. Data Governance and Consent Management, Data governance policies define roles, responsibilities, and processes for managing and safeguarding patient data within healthcare organizations. Consent management frameworks outline procedures for obtaining patient consent, providing transparency, and respecting patient preferences regarding the use and disclosure of their health information (Ewim et al., 2023).

Regulatory Compliance Requirements, Healthcare organizations must comply with regulatory requirements and accreditation standards for Health IT systems, such as EHR certification criteria, meaningful use requirements, and quality reporting programs. Regulatory bodies, such as the Centers for Medicare and Medicaid Services (CMS) and the Office of the National Coordinator for Health Information Technology (ONC), establish guidelines and incentives to promote the adoption and meaningful use of Health IT solutions (Odeleye et al., 2018).

Ethical and Legal Considerations, Ethical and legal considerations guide the responsible and ethical use of AI, ML, and block chain technologies in medication management. Regulatory frameworks address issues related to data privacy, algorithm transparency, bias mitigation, and accountability in AI-driven decision-making processes, ensuring ethical and equitable treatment of patients and adherence to professional standards of care (Olushola, 2023).

In conclusion, the adoption and implementation of AI, ML, block chain technology, interoperability efforts, patient engagement strategies, and regulatory frameworks have significant implications for medication management in healthcare. By leveraging innovative technologies, standardization efforts, patient-centered approaches, and policy initiatives, healthcare organizations can enhance medication safety, improve treatment outcomes, and advance patient-centered care delivery (Kasten et al., 2023).

7. Future Research

Long-Term Impact Studies, Future research should conduct longitudinal studies to assess the long-term impact of HIT solutions on medication management outcomes, including medication adherence, patient satisfaction, healthcare utilization, and clinical outcomes. Comparative effectiveness research can evaluate the effectiveness of different HIT interventions and identify best practices for implementation (Adeniyi et al., 2020). Health Equity Research, Research should explore the role of HIT in addressing health disparities and promoting health equity in medication management.

Studies should examine the impact of HIT interventions on access to care, treatment disparities, and health outcomes among diverse patient populations, including racial and ethnic minorities, socioeconomically disadvantaged groups, and rural communities. Ethical and Legal Considerations, Further research is needed to investigate ethical and legal considerations related to the use of AI, ML, and block chain technology in medication management. Studies should examine issues such as data privacy, algorithm transparency, bias mitigation, and patient consent in HIT-driven decision-making processes, ensuring ethical and equitable treatment of patients (Abdulkadir et al., 2022).

Cost-Effectiveness Analysis, Economic evaluations should assess the cost-effectiveness of HIT interventions in medication management, considering both short-term and long-term costs and benefits. Cost-effectiveness analyses can inform healthcare decision-makers and policymakers about the value and return on investment of implementing HIT solutions in clinical practice. In conclusion, advancements in HIT, interoperability efforts, patient engagement strategies, and policy frameworks have significant implications for medication management in healthcare.

Practice and policy initiatives should prioritize patient-centered care, health equity, and ethical considerations while leveraging HIT solutions to enhance medication safety, improve treatment outcomes, and optimize healthcare delivery. Future research should focus on assessing the long-term impact, health equity implications, ethical considerations, and cost-effectiveness of HIT interventions in medication management, guiding evidence-based practice and policy development in healthcare.

8. Conclusion

Healthcare Information Technology (HIT) Advances, The integration of Artificial Intelligence (AI), Machine Learning (ML), and block chain technology has transformed medication management, improving medication safety, adherence, and patient outcomes. Interoperability and Standardization Efforts, Efforts to enhance interoperability and standardization have facilitated seamless data exchange across healthcare systems, enabling better care coordination and continuity. Patient Engagement Strategies, Patient engagement strategies, such as patient education, shared decision-making, and remote monitoring, have empowered patients to actively participate in their medication management and healthcare decisions. Policy Implications and Regulatory Frameworks, Regulatory frameworks and policies play a crucial role in shaping the adoption, implementation, and ethical use of HIT solutions in medication management, ensuring patient privacy, data security, and regulatory compliance. Implications for Practice and Policy, Practice Implications, Healthcare organizations should prioritize the adoption and implementation of HIT solutions, including AI, ML, and block chain technology, to enhance medication safety, improve care quality, and optimize treatment outcomes. Interdisciplinary collaboration, stakeholder engagement, and user-centered design are essential for successful HIT implementation and adoption. Policy Implications, Policymakers should enact policies and regulations that promote interoperability, data exchange, and patient engagement in medication management. Regulatory frameworks should address ethical, legal, and privacy considerations related to the use of AI, ML, and block chain technology in healthcare, ensuring transparency, accountability, and patient safety. Patient-Centered Care, Patient-centered care should be prioritized in medication management practices, with a focus on empowering patients to actively participate in their care decisions, treatment plans, and medication adherence. Patient education, shared decision-making, and remote monitoring tools should be integrated into clinical workflows to enhance patient engagement and satisfaction. Health Equity and Access, HIT solutions should be designed and implemented with a focus on addressing health disparities, improving access to care, and promoting health equity. Telemedicine, remote monitoring, and mobile health applications can expand access to medication management services for underserved populations, rural communities, and vulnerable patient groups.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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