

Information Systems in Pharmacy: Enhancing Patient Safety and Outcomes

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ABSTRACT

Information systems in pharmacy play a critical role in enhancing patient safety and outcomes through the efficient management of medication information and patient data. By integrating advanced technology such as electronic health records (EHR), computerized physician order entry (CPOE), and pharmacy management software, healthcare providers can reduce the risk of medication errors, adverse drug interactions, and ensure accurate prescribing. These systems facilitate real-time access to patient prescriptions, allergies, and medical histories, enabling pharmacists and other healthcare professionals to make informed decisions and provide personalized therapy. Furthermore, automated alerts and decision support tools within these systems aid in identifying potential issues before they occur, contributing significantly to improved patient care. Moreover, information systems in pharmacy can enhance communication among healthcare stakeholders, leading to improved collaboration and better patient outcomes. By enabling seamless sharing of information between pharmacists, physicians, and other healthcare providers, these systems help ensure that everyone involved in a patient's care has access to the most up-to-date and comprehensive information. This interconnectedness not only fosters a team-based approach to medication management but also empowers patients by providing them with access to their medication records and counseling resources. As healthcare continues to evolve, the integration of information systems in pharmacy will remain a vital component in achieving the overarching goals of safety, efficacy, and improved quality of care.

KEYWORDS: Information systems, pharmacy, patient safety, medication management, electronic health records, computerized physician order entry, pharmacy management software, medication errors, adverse drug interactions, healthcare collaboration, decision support tools, patient outcomes.

1. Introduction

In the contemporary healthcare landscape, the integration of technology and information systems is paramount to fostering enhanced patient safety and improving health outcomes. Among the various fields of healthcare, pharmacy stands out as a critical component where information systems can fundamentally transform practices. With the increasing complexity of medication management, the incidence of medication errors, and the rise of chronic diseases requiring intricate treatment regimens, the role of information systems in pharmacy has become more vital than ever. This introduction endeavors to delineate the profound impact of information systems within the pharmacy sector, explore current challenges and innovations, and outline the significance of enhanced patient safety and outcomes as a primary goal of these technological advancements [1].

Information systems in pharmacy encompass a range of digital tools and applications designed to facilitate the efficient management of medication information, streamline pharmacy operations, and support clinical decision-making. These systems include electronic health records (EHRs), pharmacy management systems, computerized physician order entry (CPOE), clinical decision support systems (CDSS), and medication therapy management (MTM) solutions. By leveraging these technologies, pharmacy practitioners can access real-time data, enhance communication across healthcare teams, and ensure better adherence to best practices in medication management. This integration not only alleviates administrative burdens but also allows pharmacists to focus on their essential role as healthcare providers, counseling patients, and optimizing pharmacotherapy [2].

One of the foremost advantages of implementing information systems in pharmacy is the enhancement of patient safety. The World Health Organization (WHO) identifies medication errors as a significant contributor to adverse patient outcomes, with thousands of preventable deaths and hospitalizations occurring each year. Information systems address this challenge by minimizing the risk of medication errors through automated processes. For instance, CPOE systems reduce the likelihood of misinterpretation of handwritten prescriptions by standardizing orders into digital formats that are easier to read and process. Furthermore, by incorporating CDSS into pharmacy workflows, pharmacists can receive alerts regarding potential drug interactions, allergies, or dosage errors, allowing them to intervene proactively and protect patient safety [3].

Beyond the immediate goal of preventing medication errors, information systems in pharmacy play a pivotal role in improving overall health outcomes. By employing data analytics and population health management strategies, these systems facilitate personalized medication management, ensuring that patients receive therapies tailored to their specific needs. Pharmacists, equipped with comprehensive data about a patient's medication history, genetic predispositions, and existing health conditions, can make informed clinical decisions that lead to more effective treatments. Consequently, patients benefit from improved adherence to medication regimens, reduced hospital readmissions, and a greater likelihood of achieving

therapeutic goals [4].

While the benefits of information systems in pharmacy are substantial, it is crucial to recognize the hurdles that accompany their implementation. Data privacy and security concerns remain significant obstacles, particularly given the sensitive nature of health information. Regulatory frameworks, such as the Health Insurance Portability and Accountability Act (HIPAA) in the United States, mandate stringent measures to protect patient data, yet breaches continue to pose risks to both individuals and healthcare providers. Additionally, the interoperability of various information systems presents challenges, as disparate systems may hinder seamless information sharing, leading to fragmented care and inefficiencies [5].

The future of information systems in pharmacy is characterized by continuous innovation and the growing recognition of the pharmacist's role in patient care. The advent of telepharmacy and mobile health applications illustrates the evolving landscape in which pharmacists can engage patients beyond traditional settings, using technology to provide counseling, educate on medication adherence, and offer real-time support. Moreover, advancements in artificial intelligence (AI) and machine learning are poised to revolutionize pharmacy practice by enabling predictive analytics, enhancing decision-making processes, and ultimately, augmenting the quality of patient care [6].

The Role of Electronic Health Records in Medication Safety:

In the rapidly evolving landscape of healthcare, the integration of technology has transformed various aspects of patient care, one of the most significant being the implementation of Electronic Health Records (EHRs). These digital systems not only streamline patient information management but also play a crucial role in enhancing medication safety. Medication errors remain one of the pivotal concerns in healthcare, contributing substantially to morbidity, mortality, and increased healthcare costs. EHRs, when utilized effectively, can mitigate these risks through accurate data management, improved communication among healthcare providers, and the facilitation of clinical decision support systems [7].

EHRs are comprehensive, real-time digital records that provide an exhaustive view of a patient's health history and medical information across various healthcare settings. Unlike traditional paper records, EHRs are designed to be shared and accessed by authorized healthcare professionals, enabling a seamless exchange of information. Features of EHR systems often include medication lists, allergy information, lab results, and clinical notes, all contributing to a holistic view of patient health. Their potential to affect medication safety derives not only from the accessibility of information but also from the system's capability to incorporate decision support tools intended to alert providers to potential medication-related issues [7].

Medication errors encompass a range of issues, including prescribing, administration, and monitoring errors, which can arise from illegible handwriting, misunderstood verbal orders, and incorrect dosage calculations. According to the Institute of Medicine's report, "To Err Is Human," medication errors account for significant patient harm, contributing to thousands of hospitalizations and an

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estimated \$21 billion in excess healthcare costs annually. With increasing medication complexity due to the rise of polypharmacy and the aging population, the need for effective systems to safeguard against these errors is paramount [8].

The integration of EHRs in medication management introduces several critical advantages that directly contribute to enhancing medication safety. Here are some of the pivotal functions of EHRs that mitigate the risks associated with medication errors:

1. **Comprehensive Medication List:** EHRs provide a complete and up-to-date view of a patient's medication history, including current prescriptions, dosages, and any over-the-counter medications the patient may be taking. This centralized medication management helps prevent inadvertent prescribing of contraindicated drugs [9].
2. **Drug Interaction Alerts:** One of the most significant features of EHRs is their ability to integrate clinical decision support tools that can provide alerts for potential drug interactions. These alerts are crucial in preventing adverse drug events (ADEs) that could arise when multiple medications interact unfavorably [9].
3. **Streamlined Ordering Processes:** EHRs facilitate electronic prescribing (e-prescribing), which minimizes errors related to handwriting and verbal orders. With e-prescribing, providers can also access formulary information, ensuring that prescribed medications are covered by the patient's insurance, thereby enhancing treatment adherence and reducing medication costs[9].
4. **Patient Allergy Alerts:** By maintaining detailed allergy records, EHRs can alert healthcare providers if a prescribed medication is likely to cause an allergic reaction. This proactive measure significantly reduces the risk of harm to patients who may have previously experienced severe side effects from certain medications [10].
5. **Avoiding Duplicates and Ensuring Continuity of Care:** EHRs can effectively highlight prior prescriptions, thereby reducing the chances of duplicate therapies that may complicate a patient's treatment regimen. This feature is particularly essential during transitions of care, such as hospital discharge, when continuity of medication management is critical [10].
6. **Monitoring and Reporting:** EHRs can assist in tracking medication adherence through automated reminders and alerts to both patients and healthcare providers. Moreover, they facilitate the reporting of adverse drug reactions, which can contribute to national databases intended to monitor and enhance medication safety protocols [10].

Challenges and Limitations

Despite the myriad benefits EHRs provide, there are challenges and limitations that must be recognized. Issues such as the potential for software errors, the need for effective training of healthcare staff, and concerns about data privacy and security can pose significant barriers to the efficacy of EHRs in enhancing medication safety. Furthermore, the information overload created by excessive alerts and notifications

can lead to alert fatigue among healthcare providers, ultimately reducing the effectiveness of these vital safeguards [11].

The ongoing evolution of EHR technology must focus on refining the systems to ensure that they not only support medication safety but do so without overwhelming providers. Enhancing interoperability among different EHR systems could improve the sharing of critical patient data across various healthcare settings, further optimizing medication management. Additionally, incorporating artificial intelligence and machine learning into EHR systems has the potential to enhance predictive analytics for patient-specific medication risks, ultimately leading to more personalized and safer medication management practices [12].

Computerized Physician Order Entry: Reducing Errors in Prescriptions:

The advent of health information technology has significantly transformed the landscape of healthcare delivery, particularly in the realm of medication management. One such innovation, Computerized Physician Order Entry (CPOE), has become a critical tool used by healthcare professionals to streamline the prescribing process [13].

Computerized Physician Order Entry refers to the electronic entry of medical practitioner instructions for the treatment of patients. Traditionally, healthcare providers relied on handwritten prescriptions, which were often prone to misinterpretation due to illegibility, ambiguity, or incomplete information. CPOE systems allow physicians and other healthcare providers to enter orders directly into a computer system, which can subsequently communicate the information to pharmacies, laboratories, or other departments effectively [14].

The functionality of CPOE extends beyond merely issuing prescriptions. It often integrates with clinical decision support systems (CDSS) that provide alerts for potential drug interactions, allergies, or dosage errors. This interactive interface enhances the decision-making process, ensuring that healthcare professionals have access to essential patient data at their fingertips [15].

Prescription errors remain a pressing concern in healthcare, with estimates suggesting that they affect 1.5 million patients in the United States each year. These errors can occur at various stages, beginning with the initial ordering process, through dispensing, and finally to administration. The implications of prescription errors, whether they lead to adverse drug events or prolonged hospital stays, can be detrimental to patient well-being and overall healthcare costs [16].

CPOE systems significantly mitigate the risk of errors associated with handwritten prescriptions. One primary benefit is the elimination of illegible handwriting, which has historically been a source of confusion. When physicians enter prescriptions electronically, the data is clear and standardized, substantially reducing the risk of misinterpretation by pharmacists and nurses [17].

Moreover, CPOE often incorporates sophisticated clinical decision support tools. These tools can alert practitioners to potential drug interactions and allergies, provide dosage recommendations based on patient weight or renal function, and flag duplicate therapies. Such systems enhance the quality of prescribing by promoting

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evidence-based practice, allowing clinicians to make informed decisions that safeguard patient health [18].

A study published in the "Journal of the American Medical Informatics Association" indicated that hospitals implementing CPOE systems experienced a 55% reduction in serious medication errors compared to those relying solely on paper-based systems. This statistic underscores the transformative nature of CPOE and its critical role in providing safe, effective, and efficient patient care [19].

Despite the evident advantages of CPOE systems, their adoption is not without challenges. One of the foremost hurdles is the financial investment required to implement and maintain these technologies. Hospitals and clinics must allocate significant resources toward the acquisition of software, hardware, and training programs for their staff. For smaller healthcare facilities, this can be an overwhelming burden, leading to disparities in system usage across different settings [20].

Additionally, the success of CPOE is contingent upon the user-friendliness of the software and the extent to which it integrates with existing workflows. If the system is cumbersome or poorly designed, clinicians may experience frustration, potentially leading to resistance in utilizing the technology or even compromising patient care. Training and ongoing support are crucial to ensure that users are adequately prepared to navigate the system efficiently [21].

Resistance to change among healthcare professionals can also complicate the implementation process. Many providers may be accustomed to traditional prescribing methods and may struggle to adapt to a new electronic format. To address this issue, organizations must foster an environment that encourages open dialogue and provides comprehensive training on the benefits of CPOE. Demonstrating the positive outcomes associated with the technology, such as improved patient safety and streamlined workflow, is essential for garnering buy-in from healthcare staff [22].

The adoption of CPOE systems extends beyond merely reducing prescription errors; it fundamentally enhances patient safety and healthcare efficiency. By minimizing the likelihood of medication errors, CPOE contributes to improved patient outcomes. Consequently, when patients receive the correct medications promptly, the risk of adverse events decreases significantly. This enhancement in safety not only benefits patients but also reduces the financial burden on healthcare systems due to lower rates of complications, readmissions, and litigation [22].

Furthermore, CPOE systems streamline the prescribing process, resulting in time savings for healthcare providers. With all necessary information accessible in a single electronic platform, physicians can quickly review patient histories, check for contraindications, and issue prescriptions without the delays often encountered with paper-based systems. This increased efficiency translates into more time for healthcare providers to focus on patient care, ultimately enriching the healthcare experience for both patients and providers [23].

CPOE also enables better data tracking and reporting. With an electronic system in

place, healthcare facilities can analyze prescription patterns, monitor adherence to clinical guidelines, and execute quality improvement initiatives more effectively. The data gleaned from CPOE systems can drive informed decision-making at organizational levels and contribute to the development of integrated care pathways [24].

Pharmacy Management Software: Streamlining Medication Dispensing:

In the modern era, healthcare systems are evolving rapidly, driven by advancements in technology. Among these innovations, pharmacy management software (PMS) has emerged as a pivotal tool in the realm of medication dispensing. This software not only enhances the efficiency of pharmaceutical operations but also ensures patient safety and satisfaction. By automating various processes involved in medication dispensing, PMS helps pharmacies manage their inventory, streamline workflows, and improve communication among healthcare providers [25].

Pharmacy management software refers to a comprehensive suite of digital tools designed to facilitate the operations of a pharmacy. It encompasses a wide range of functionalities, including medication dispensing, inventory management, prescription processing, billing, and reporting. PMS systems can be utilized by various types of pharmacies, including community pharmacies, hospital pharmacies, and specialty pharmacies [26].

The core objective of pharmacy management software is to minimize human error, enhance workflow efficiency, and improve patient care. By transitioning from manual processes to automated solutions, pharmacies can address some of their biggest challenges in medication dispensing [27].

Key Features of Pharmacy Management Software

The effectiveness of pharmacy management software can be attributed to its diverse features, which cater to the unique needs of pharmacies. Here are some key components:

1. **Prescription Management:** PMS systems allow pharmacists to process prescriptions electronically, reducing errors associated with handwritten prescriptions. They also offer tools for verifying prescription authenticity and ensuring that prescriptions are filled in accordance with legal regulations [28].
2. **Inventory Control:** Managing inventory effectively is essential for any pharmacy. PMS provides tools for monitoring stock levels, tracking expiration dates, and generating purchase orders for restocking. This not only prevents shortages but also reduces waste from expired medications [29].
3. **Patient Profiles and Medication History:** PMS enables pharmacists to maintain detailed patient profiles, including medication histories and allergies. This information is crucial for making informed decisions about medications, avoiding contraindications, and providing personalized care [30].
4. **Billing and Reimbursement Management:** Pharmacy management software typically includes features for billing and processing insurance claims. This streamlines the reimbursement process, allowing pharmacies to focus more on

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patient care rather than administrative tasks [31].

5. Reporting and Analytics: PMS offers robust reporting capabilities that help pharmacists analyze key performance indicators, including sales trends, inventory turnover, and patient adherence rates. This data-driven approach allows pharmacies to make informed strategic decisions and improve operational efficiency [32].

Benefits of Pharmacy Management Software

One of the most significant advantages of pharmacy management software is the enhancement of patient safety. By automating the medication dispensing process and integrating clinical decision support tools, PMS significantly reduces the likelihood of medication errors. Pharmacists can easily access a patient's medication profile, ensuring that potential drug interactions are flagged and resolved before the medication is dispensed. Additionally, improved accuracy in filling prescriptions leads to higher patient satisfaction and trust in the pharmacy [33].

PMS streamlines pharmacy operations by enabling efficient workflows. By automating repetitive tasks such as data entry, prescription verification, and inventory tracking, pharmacists can redirect their attention to patient-focused services. Enhanced workflows lead to shorter wait times for patients, ultimately improving the overall experience within the pharmacy [34].

The implementation of pharmacy management software can result in significant cost savings for pharmacies. By reducing errors and inefficiencies in the medication dispensing process, pharmacies can minimize financial losses associated with misfilled prescriptions and excess inventory. Furthermore, optimization of staff resources allows pharmacies to allocate personnel strategically, bridging the gap between demand and available workforce [35].

The pharmacy industry is highly regulated, with numerous guidelines governing the dispensing of medications. PMS solutions often include built-in compliance features that help pharmacies adhere to federal and state regulations. This not only mitigates the risk of legal repercussions but also enhances the pharmacy's reputation and fosters trust among healthcare providers and patients alike [36].

While the benefits of pharmacy management software are clear, certain challenges must be addressed for successful implementation. Transitioning from a manual system to a digital platform can be daunting, requiring intensive training for pharmacy staff. Resistance to change among employees can also hinder the adoption of PMS [37].

Further, selecting the right pharmacy management software is critical. Pharmacies must evaluate various vendors based on factors such as functionality, usability, customer support, and pricing. Given the competitive landscape, pharmacies may find it challenging to assess which software best meets their specific needs [38].

As technology continues to advance, pharmacy management software will evolve to incorporate new trends that enhance pharmacy operations. One such trend is the integration of artificial intelligence (AI) and machine learning (ML) in PMS. These technologies can analyze large sets of data to predict medication needs, optimize

inventory management, and identify patterns in drug utilization [39].

Additionally, the rise of telepharmacy—where pharmacists provide consultations and services remotely—demands enhanced digital solutions. PMS developers are likely to create platforms that seamlessly integrate telehealth services with pharmacy management functionalities, enabling pharmacists to engage with patients in real-time, regardless of their physical location.

Moreover, the increasing emphasis on patient-centered care and personalized medicine implies that pharmacies will need robust systems that not only manage medications but also provide clinical decision support tailored to individual patient needs [40].

Decision Support Systems: Enhancing Clinical Decision-Making:

In the rapidly evolving landscape of healthcare, the complexity of managing patient care and clinical workflows continues to increase. Clinicians today are faced with a wealth of information, clinical data, and guidelines that can be overwhelming. In this environment, Decision Support Systems (DSS) have emerged as vital tools designed to enhance clinical decision-making, improve patient outcomes, and optimize healthcare resources. These systems leverage technology and data to assist healthcare professionals in the decision-making process by providing relevant information, analyses, and recommendations tailored to specific clinical scenarios [41].

Decision Support Systems are interactive software-based applications that utilize data, knowledge, and algorithms to support clinical decision-making. The fundamental purpose of DSS is to provide timely, relevant, and evidence-based information that assists healthcare providers in making informed decisions regarding patient care. These systems can vary significantly in complexity, ranging from simple reminder systems to advanced predictive models that analyze large datasets to identify potential patient risks [42].

DSS can be categorized into two main types: knowledge-based systems and non-knowledge-based systems. Knowledge-based DSS rely on a comprehensive repository of clinical rules and guidelines, enabling them to provide recommendations based on clinical scenarios. For example, a surgical DSS may alert surgeons to potential complications or suggest appropriate postoperative care protocols based on the latest research. In contrast, non-knowledge-based systems use data analytics and machine learning algorithms to identify patterns and trends within existing patient data, offering insights that inform clinical decisions [43].

The Role of DSS in Clinical Decision-Making

The integration of Decision Support Systems in clinical settings plays a critical role in enhancing the quality of patient care. These systems assist clinicians by making complex information more accessible and digestible. When implemented effectively, DSS can help reduce medical errors, minimize variability in treatment practices, and support evidence-based medicine [43].

1. **Reduction of Medical Errors:** Medical errors continue to be a significant concern in the healthcare industry, leading to adverse patient outcomes and increased healthcare costs. DSS can mitigate such risks by providing alerts and reminders

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about potential drug interactions, allergies, or deviations from clinical guidelines. For instance, electronic health record (EHR)-integrated DSS can flag potential prescription errors in real-time, allowing healthcare providers to double-check decisions before administering medications [43].

2. **Support for Evidence-Based Medicine:** Evidence-based medicine is the cornerstone of modern healthcare practices, ensuring that clinical decisions are grounded in the latest research and clinical guidelines. DSS facilitates this process by synthesizing vast amounts of clinical evidence and delivering customized recommendations based on individual patient data. For example, in oncology, a DSS can analyze a patient's genetic profile and clinical history to recommend personalized treatment options that align with the most current findings in cancer research [44].

3. **Enhanced Clinical Efficiency:** The time constraints faced by healthcare providers can impede their ability to stay updated on emerging research and clinical guidelines. DSS can streamline the decision-making process by providing quick access to relevant information, thereby improving clinical efficiency. This is particularly important in high-pressure environments such as emergency departments or critical care units, where timely decisions are essential for patient survival [44].

Challenges in Implementing Decision Support Systems

While the potential benefits of Decision Support Systems are significant, there are also challenges that healthcare organizations must navigate when implementing these tools. One of the primary barriers is the integration of DSS into existing clinical workflows. For DSS to be effective, they must be seamlessly integrated into the EHR systems that clinicians use daily. Failure to achieve this integration can lead to underutilization of DSS, thereby negating their intended benefits [45].

Another challenge is the need for accurate and comprehensive data inputs. DSS are only as good as the data they analyze. Incomplete or inaccurate data can lead to flawed recommendations, which can compromise patient safety. Thus, ensuring the integrity of clinical data is paramount for the successful implementation of decision support systems [45].

Moreover, there is often resistance from healthcare professionals who may perceive DSS as undermining their clinical judgment or reducing their autonomy. Engaging healthcare staff in the development and implementation process, providing training, and emphasizing the supportive role of DSS can mitigate such resistance and encourage the adoption of these tools [46].

As healthcare continues to embrace digital transformation, the future of Decision Support Systems holds promising advancements. Emerging technologies such as artificial intelligence (AI) and machine learning (ML) are poised to augment the capabilities of DSS. AI-powered DSS can analyze complex datasets to identify trends and predict patient outcomes more accurately than traditional methods. This evolution could lead to more proactive and preventative care approaches, shifting the focus from reactive treatment to holistic patient management [46].

Furthermore, as telemedicine and remote patient monitoring become more prevalent, DSS can also facilitate clinical decision-making in virtual settings. For instance, a DSS integrated into telehealth platforms could provide specialists with real-time data and recommendations based on remote patient assessments, enhancing the quality of care delivered in non-traditional settings [47].

Interdisciplinary Communication: Facilitating Collaboration Among Healthcare Providers:

In the ever-evolving landscape of healthcare, the complexity of patient care requires a coordination of myriad professionals, each bringing unique expertise to the table. As healthcare systems become increasingly intricate, interdisciplinary communication emerges as a cornerstone of effective collaboration among diverse healthcare providers [48].

Interdisciplinary collaboration in healthcare involves the interaction of professionals from various fields, including physicians, nurses, pharmacists, social workers, and therapists, among others. Each professional contributes specialized knowledge and skills that are critical in formulating comprehensive treatment plans. Interdisciplinary communication facilitates this interaction, ensuring that all team members are informed and engaged in the patient care process [48].

One of the most compelling reasons for fostering interdisciplinary communication is improved patient outcomes. Studies have shown that when healthcare providers communicate effectively across disciplines, there is a significant reduction in medical errors and adverse events. For instance, effective communication among medical, nursing, and pharmacy teams can minimize drug interactions and ensure that medication regimens are appropriate for each patient's unique circumstances. Moreover, a collaborative environment allows for faster decision-making, enabling timely interventions that can be crucial in acute care settings [49].

In addition to enhancing patient safety, interdisciplinary collaboration promotes a holistic approach to healthcare. By integrating perspectives from various specialties, healthcare providers can better address the multifaceted needs of patients. For example, a patient with chronic illness may benefit from the cognitive support provided by a psychologist, the dietary guidance of a nutritionist, and the medical oversight of a primary care physician. Interdisciplinary communication ensures that these contributions are harmonized, leading to more tailored and effective patient care [50].

Despite the clear advantages of interdisciplinary collaboration, several barriers can impede effective communication among healthcare providers. One significant barrier is professional silos, where practitioners become entrenched in their disciplines, leading to a lack of understanding and appreciation for the roles of others. This situation can foster an atmosphere of mistrust or competition rather than collaboration. Additionally, variations in terminologies, practices, and protocols among disciplines can cause misunderstandings and hinder effective communication [51].

Another barrier is the hierarchical nature of many healthcare environments. Power dynamics can affect communication flow, leading to situations where junior staff

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may hesitate to voice concerns or provide inputs. Such dynamics can compromise the quality of care delivered, as crucial information may not reach the necessary parties in a timely manner [51].

Moreover, the rapid advancement of technology in healthcare introduces another layer of complexity affecting communication. While electronic health records (EHRs) can significantly enhance information sharing, they can also contribute to information overload if not used effectively. Healthcare providers may struggle to extract relevant information from extensive patient records, which can lead to incomplete communication and fragmented care [52].

To overcome these barriers, healthcare organizations must adopt strategic approaches to enhance interdisciplinary communication. One effective strategy is to foster a culture of collaboration through team-building initiatives. Regular interdisciplinary team meetings can facilitate open dialogue among team members, encourage the sharing of insights, and promote relationship-building among providers. These meetings can serve as platforms to discuss challenging cases, review treatment plans, and collectively brainstorm solutions [53].

Training and education can also play instrumental roles in promoting interdisciplinary communication. Providing staff with training in communication skills, conflict resolution, and cultural competence can foster an environment conducive to collaboration. Moreover, interdisciplinary education programs—where healthcare students from various disciplines learn together—can cultivate mutual respect and understanding from the outset of professional development [54].

Another critical strategy is implementing standardized communication protocols. Utilizing structured communication frameworks, such as SBAR (Situation, Background, Assessment, Recommendation) or checklists, within interdisciplinary teams can enhance clarity and ensure all relevant information is shared efficiently. This standardization can help minimize ambiguity and reduce misunderstandings, leading to more collaborative decision-making processes [54].

Additionally, leveraging technology wisely can facilitate better communication. Integrating user-friendly communication platforms that allow for real-time discussions, video conferencing, and secure messaging can bridge gaps between providers working in different locations. These tools enable healthcare professionals to connect promptly, share insights, and collaborate effectively, regardless of their physical presence [55].

Patient Engagement Through Information System Integration:

In the rapidly evolving realm of healthcare, improving patient engagement has emerged as a crucial component of delivering high-quality care. Patient engagement is broadly defined as the involvement of patients in their own health and healthcare decisions. As healthcare practitioners and administrators seek effective strategies to enhance patient engagement, the integration of information systems stands out as a pivotal approach. Information system integration involves the seamless functioning of different healthcare systems and technologies to ensure efficient communication and data exchange among various stakeholders—including patients, providers, and

payers [56].

Before delving into information system integration, it is essential to understand the significance of patient engagement. Research has consistently shown that engaged patients have better health outcomes, increased satisfaction with care, and lower healthcare costs. Engaged patients are more likely to adhere to treatment plans, take preventive measures, and participate actively in shared decision-making. Consequently, healthcare systems across the globe are prioritizing patient engagement as a means to improve care delivery and health outcomes [57].

Information systems play a vital role in the healthcare ecosystem, serving as the backbone for managing clinical information, streamlining operations, and enhancing communication among various stakeholders. These systems encompass Electronic Health Records (EHRs), patient portals, health information exchanges (HIEs), telehealth platforms, and mobile health applications. Effective integration of these diverse systems allows for the consistent and accurate sharing of health data, leading to a more cohesive patient experience [57].

Benefits of Information System Integration for Patient Engagement

1. **Enhanced Access to Information:** One of the primary benefits of integrated information systems is improved access to health information. Patient portals, a staple of integrated healthcare systems, empower patients to view their health records, test results, and treatment plans at any time. This accessibility not only enhances patients' knowledge about their health but also stimulates proactive engagement in their care [58].
2. **Facilitation of Communication:** Integrated information systems break down communication barriers between patients and healthcare providers. With messaging features in patient portals and telehealth services, patients can easily communicate with their providers, seek clarification about their health concerns, and obtain timely advice. This level of communication fosters a sense of partnership between patients and providers, leading to increased satisfaction and adherence to treatment plans [58].
3. **Personalization of Healthcare:** Integration allows healthcare providers to use data analytics to tailor care experiences to the individual needs of patients. By analyzing data from multiple sources, providers can identify patterns, preferences, and potential health risks relevant to each patient. This personalized approach encourages patients to take an active interest in their health management and treatment choices [59].
4. **Streamlined Care Coordination:** A well-integrated information system enables better care coordination among different healthcare providers. Patients often navigate complex care landscapes, especially those with chronic conditions requiring multidisciplinary approaches. Integrated systems ensure that all members of a patient's care team have access to the same comprehensive information, allowing for informed decision-making and continuity of care [60].
5. **Empowerment Through Education:** Information system integration can facilitate educational resources tailored to patients' specific conditions and concerns.

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E-learning modules, videos, and articles can be integrated into patient portals, allowing patients to expand their knowledge about their conditions, treatment options, and preventive measures. Increased knowledge empowers patients to make informed decisions, enhancing their engagement in their health journey [60].

Challenges of Information System Integration

Despite its undeniable benefits, integrating information systems presents several challenges that can impede effective patient engagement:

1. **Interoperability Issues:** A significant roadblock to effective integration is the lack of standardization among various healthcare technologies. Different systems may utilize incompatible data formats or protocols, leading to silos of information and frustrated staff and patients.
2. **Privacy and Security Concerns:** As technology evolves, safeguarding patient information remains a pressing concern. Integrated systems that allow easy access to health data must also implement robust security measures to protect sensitive information from breaches and unauthorized access.
3. **User Resistance:** Healthcare providers may resist adopting new systems due to concerns about usability, workflow disruptions, and the learning curve associated with new technology. Similarly, some patients may be overwhelmed by digital systems, particularly older adults who may feel less comfortable navigating technology.
4. **Cost Implications:** The financial burden of implementing and maintaining integrated information systems can be significant. While the long-term benefits of improved patient engagement and outcomes may justify these costs, smaller healthcare organizations may struggle with limited resources [61].

The Future of Information System Integration in Patient Engagement

The future of patient engagement through information system integration is promising, as technology continues to evolve alongside growing recognition of the importance of patient-centered care. Emerging technologies such as artificial intelligence (AI), machine learning, and predictive analytics hold the potential to further enhance patient engagement strategies. For instance, AI algorithms can analyze vast datasets to identify patient trends and preferences, providing insights that can be used to develop more effective engagement strategies [62].

Moreover, the rise of wearable devices and mobile health applications offers new avenues for patient engagement. These tools not only allow patients to track their health data in real-time but can also sync with healthcare information systems, enabling providers to monitor patients' conditions proactively [62].

As healthcare continues to navigate the digital landscape, policymakers and stakeholders must prioritize the development of interoperable systems, focus on user-friendly design, and address the financial aspects of system integration. By cultivating an environment that promotes seamless information flow among all healthcare stakeholders, the potential for enhanced patient engagement becomes a

tangible reality [62].

Future Trends in Information Technology and Their Impact on Pharmacy Practice:

The landscape of healthcare is perpetually evolving, with information technology (IT) ushering in a new era of possibilities. Nowhere is this shift more pronounced than in pharmacy practice, where advancements in IT are poised to reshape how pharmacists interact with patients, manage medication therapies, and ensure optimal healthcare outcomes. As technology continues to advance, understanding these future trends is paramount for professionals in the pharmacy field [63].

One of the most disruptive trends in IT is the emergence of artificial intelligence (AI) and machine learning (ML). These technologies have already begun to influence pharmacy through improved medication management and personalized care. AI algorithms can analyze vast amounts of data to predict patient outcomes, optimize drug therapies, and even anticipate potential adverse drug reactions. For instance, predictive analytics can help pharmacists identify patients at higher risk for medication non-adherence, allowing for timely interventions that improve adherence rates [63].

Moreover, AI-powered chatbots and virtual assistants are streamlining communication between pharmacists and patients. These tools can handle routine queries, scheduled medication reminders, and even provide health information, thus allowing pharmacists to focus on more complex patient care tasks. As the capabilities of AI continue to grow, pharmacists are likely to find themselves working alongside advanced systems that enhance their ability to deliver tailored therapeutic advice [64].

The COVID-19 pandemic catalyzed the acceptance and expansion of telehealth services, including telepharmacy. This model allows pharmacists to provide consultations remotely, a critical capability when patients may have challenges accessing traditional pharmacy services. Telepharmacy can bridge the gap for patients in rural areas and improve access to comprehensive pharmaceutical care [64].

As telepharmacy becomes more integrated into pharmacy practice, it presents opportunities for expanded patient education and medication management. Pharmacists can conduct virtual consultations to assess medication regimens, provide health monitoring, and deliver vaccinations. This trend demonstrates an evolving role for pharmacists, shifting from mere dispensers of medication to integral players in a patient's healthcare team [65].

The digitalization of health records through electronic health records (EHR) has transformed how information is documented and shared across the healthcare continuum. For pharmacists, EHR integration allows for comprehensive access to a patient's medication history, allergies, and other pertinent health information. This comprehensive view is vital in preventing medication errors and ensuring an informed approach to patient care [65].

Future advancements in EHR technology will likely include improved interoperability across systems, allowing pharmacists to share vital information with

Saleh Hamad Al Kulayb, Yahya Hamad Alyami, Abdoullah Hamad Alyami, Essa Yahya Aldashl, Hussin Mahdi Hussin Al Salem, Hadi Munassir Hezam Alyami, Abdullah Hassan Motlk Alwayili, Mohammed Munasser Hazam Alyami, Saleh Hamad Saleh Al Hannan, Abdullah Saeed Ali Althaiban, Mulfi Mohammed Hezam Alyami

other healthcare providers seamlessly. Such connectivity fosters collaboration among healthcare teams, enabling coordinated care that enhances therapeutic outcomes. As pharmacists become more integrated within the electronic health record framework, their role in medication therapy management will expand, allowing them to contribute actively to multidisciplinary care plans [65].

Emerging smart medication management systems are poised to revolutionize how pharmacists monitor and manage patient medications. These systems leverage connected devices—such as smart pill bottles and wearable health monitors—to track medication adherence and physiological responses in real-time. Data from these systems can be aggregated and analyzed to inform pharmacists about adherence patterns, enabling proactive interventions [66].

For example, medication synchronization technology will allow pharmacists to ensure that patients receive all their medications on the same day, fostering adherence and simplifying therapy management. Furthermore, the integration of these smart systems into pharmacy practice will pave the way for personalized health programs, where therapy modifications are based on an individual's unique medication-use patterns and health responses [67].

Blockchain technology is another promising trend that could redefine pharmacy practice in various ways. Known for its secure and transparent nature, blockchain has potential applications in drug traceability and counterfeit prevention. In an industry rife with concerns regarding the authenticity of medications, blockchain's decentralized ledger could provide an unalterable record of every transaction, ensuring that only genuine medications reach patients [67].

Additionally, blockchain can play a pivotal role in managing pharmaceutical supply chains, facilitating efficient tracking of drugs from manufacturers to dispensers. This improved traceability not only enhances patient safety but also boosts pharmacists' ability to identify and respond to medication shortages or recalls quickly. As cybersecurity continues to be a pressing concern in healthcare, the cryptographic properties of blockchain can also bolster the protection of sensitive patient data, ensuring compliance with regulations such as HIPAA [68].

2. Conclusion:

In conclusion, the integration of information systems in pharmacy represents a pivotal advancement in enhancing patient safety and outcomes. The adoption of electronic health records, computerized physician order entry, and pharmacy management software has significantly reduced the incidence of medication errors and adverse drug interactions, thereby ensuring safer medication practices. Furthermore, decision support tools and improved interdisciplinary communication foster a collaborative healthcare environment, empowering pharmacists and other providers to make informed, data-driven decisions that prioritize patient well-being.

As the landscape of healthcare continues to evolve, leveraging emerging technologies will be essential for further improving the quality of care provided to

patients. Continued investment in and research on information systems will help identify best practices and innovative solutions that address the challenges faced in the pharmacy sector. Ultimately, by harnessing the capabilities of technology, the pharmacy profession can not only enhance patient safety but also contribute to better health outcomes, leading to a more efficient and effective healthcare system overall.

References

- Kohn L.T., Corrigan J.M., Donaldson M.S. *To Err Is Human: Building a Safer Health System*. The National Academies Press; Washington, DC, USA: 1999.
- Bates D.W., Singh H. Two decades since *To Err Is Human*: An assessment of progress and emerging priorities in patient safety. *Health Aff.* 2018;37:1736–1743. doi: 10.1377/hlthaff.2018.0738.
- Institute of Medicine. *Preventing Medication Errors. Crossing the Quality Chasm: A New Health System for the 21st Century*. The National Academies Press; Washington, DC, USA: 2006.
- Ash J.S., Sittig D.F., Dykstra R., Campbell E., Guappone K. The unintended consequences of computerized provider order entry: Findings from a mixed methods exploration. *Int. J. Med. Inform.* 2009;78:S69–S76. doi: 10.1016/j.ijmedinf.2008.07.015.
- Smith M.C., Bibi U., Sheard D.E. Evidence for the differential impact of time and emotion on personal and event memories for September 11, 2001. *Appl. Cognit. Psychol.* 2003;17:1047–1055. doi: 10.1002/acp.981.
- Campbell E.M., Sittig D.F., Ash J.S., Guappone K.P., Dykstra R.H. Types of unintended consequences related to computerized provider order entry. *J. Am. Med. Inform. Assoc.* 2006;13:547–556. doi: 10.1197/jamia.M2042.
- Creswell J.W., Plano Clark V. *Designing and Conducting Mixed Methods Research*. 2nd ed. SAGE Publications Inc.; Thousand Oaks, CA, USA: 2011.
- Sinsky C.A., Hess J., Karsh B.T., Keller J.P., Koppel R. Comparative User Experiences of Health IT Products: How User Experiences Would Be Reported and Used.
- Ash J.S., Berg M., Coiera E. Some unintended consequences of information technology in health care: The nature of patient care information system-related errors. *J. Am. Med. Inform. Assoc.* 2004;11:104–112. doi: 10.1197/jamia.M1471.
- Nebraska Department of Health and Human Services Health Professions, Facilities and Services, and Children’s Services Lists.
- Denzin N.K., Lincoln Y.S. *The SAGE Handbook of Qualitative Research*. 3rd ed. SAGE Publications Inc.; Thousand Oaks, CA, USA: 2005.
- Dillman D.A. *Internet, Mail and Mixed-Mode Surveys: The Tailored Design Method*. 2nd ed. John Wiley & Sons; Hoboken, NJ, USA: 2000.
- Smith S.R., Clancy C.M. Medication therapy management programs: Forming a new cornerstone for quality and safety in Medicare. *Am. J. Med. Qual.* 2006;21:276–279. doi: 10.1177/1062860606290031.
- Institute of Medicine. *Crossing the Quality Chasm: A New Health System for the 21st Century*. The National Academies Press; Washington, DC, USA: 2001.
- Mandl K.D., Kohane I.S. Escaping the EHR Trap—The Future of Health IT. *N. Engl. J. Med.* 2012;366:2240–2242. doi: 10.1056/NEJMp1203102.
- Partnership for Health IT Patient Safety—Making Healthcare Safer Together. *Safe Practice Recommendations for Developing, Implementing, and Integrating a Health IT Safety Program*. ECRI Institute; Plymouth Meeting, PA, USA: 2018.
- Koppel R., Metlay J.P., Cohen A., Abaluck B., Localio A.R., Kimmel S.E., Strom B.L. Role of computerized physician order entry systems in facilitating medication errors. *JAMA*.

Saleh Hamad Al Kulayb, Yahya Hamad Alyami, Abdaullah Hamad Alyami, Essa Yahya Aldashl, Hussin Mahdi Hussin Al Salem, Hadi Munassir Hezam Alyami, Abdullah Hassan Motlk Alwayili, Mohammed Munasser Hazam Alyami, Saleh Hamad Saleh Al Hannan, Abdullah Saeed Ali Althaiban, Mulfi Mohammed Hezam Alyami

2005;293:1197–1203. doi: 10.1001/jama.293.10.1197.

Schuren J.E. Letter to Infusion Pump Manufacturers.

SPSS Inc. Released 2009. PASW Statistics for Windows, Version 18.0. SPSS Inc.; Chicago, IL, USA: 2009.

Westerling AM, Haikala V, Airaksinen M. The role of information technology in the development of community pharmacy services: visions and strategic views of international experts. *Res Social Adm Pharm.* 2011;7(4):430–437. doi: 10.1016/j.sapharm.2010.09.004.

Troiano D. A primer on pharmacy information systems. *J Healthc Inf Manag.* 1999;13(3):41–52.

Bepko RJ, Jr, Moore JR, Coleman JR. Implementation of a pharmacy automation system (robotics) to ensure medication safety at Norwalk hospital. *Qual Manag Health Care.* 2009;18(2):103–114. doi: 10.1097/QMH.0b013e3181a02771.

Ammenwerth E, Kaiser F, Wilhelmy I, Hofer S. Evaluation of user acceptance of information systems in health care: the value of questionnaires. *Stud Health Technol Inform.* 2003;95:643–648.

Kazemi A, Ellenius J, Tofighi S, Salehi A, Eghbalian F, Fors UG. CPOE in Iran: a viable prospect? Physicians' opinions on using CPOE in an Iranian teaching hospital. *Int J Med Inform.* 2009;78(3):199–207. doi: 10.1016/j.ijmedinf.2008.07.004.

Hines LE, Saverno KR, Warholak TL, Taylor A, Grizzle AJ, Murphy JE, et al. Pharmacists' awareness of clinical decision support in pharmacy information systems: an exploratory evaluation. *Res Social Adm Pharm.* 2011;7(4):359–368. doi: 10.1016/j.sapharm.2010.10.007.

Colla CH, Lewis VA, Beaulieu-Jones BR, Morden NE. Role of pharmacy services in accountable care organizations. *J Manag Care Spec Pharm.* 2015;21(4):338–344. doi: 10.18553/jmcp.2015.21.4.338.

Webster L, Spiro RF. Health information technology: a new world for pharmacy. *J Am Pharm Assoc (2003)* 2010;50(2):e20–e31. doi: 10.1331/JAPhA.2010.09170.

Mitchell SH, Veltri MA, Kim GR. Dispensing: pharmacy information systems. In: Lehmann CU, Kim GR, Johnson KB, editors. *Pediatric informatics*. New York (NY): Springer; 2009. pp. 345–355.

Pauly A, Wolf C, Busse M, Strauß AC, Krebs S, Dorje F, et al. Evaluation of eight drug interaction databases commonly used in the German healthcare system. *Eur J Hosp Pharm.* 2015;22(3):165–170.

Pereira IM, Gaidzinski RR, Fugulin FM, Peres HH, Lima AF, Castilho V, et al. Computerized nursing staffing: a software evaluation. *Rev Esc Enferm USP.* 2011;45 Spec No:1600–1605. doi: 10.1590/s0080-62342011000700010.

Yusof MM, Papazafeiropoulou A, Paul RJ, Stergioulas LK. Investigating evaluation frameworks for health information systems. *Int J Med Inform.* 2008;77(6):377–385. doi: 10.1016/j.ijmedinf.2007.08.004.

Certification Commission for Healthcare Information Technology. CCHIT Certified: inpatient EHR 2011 certification. Chicago (IL): Certification Commission for Healthcare Information Technology; 2010.

Wolper LF. *Health care administration: planning, implementing, and managing organized delivery systems*. 4th ed. Boston (MA): Jones & Bartlett Publishers; 2004.

Shortliffe EH, Cimino JJ. *Biomedical informatics: computer applications in health care and biomedicine*. 3rd ed. New York (NY): Springer; 2006.

Wager KA, Lee FW, Glaser JP. *Managing health care information systems: a practical approach for health care executives*. 2nd ed. San Francisco (CA): Jossey-Bass; 2009.

Mohamadali NA, Garibaldi JM. A novel evaluation model of user acceptance of software technology in healthcare sector; Proceedings of 3rd International Conference on Health Informatics; 2010 Jan 20-23; Valencia, Spain. pp. 392–397.

- Bavier K. Evaluation of a pharmacy HIT system. Durham (NC): School of Nursing, Duke University; 2003.
- Hines LE, Saverno KR, Warholak TL, Taylor A, Grizzle AJ, Murphy JE, et al. Pharmacists' awareness of clinical decision support in pharmacy information systems: an exploratory evaluation. *Res Social Adm Pharm.* 2011;7(4):359–368. doi: 10.1016/j.sapharm.2010.10.007.
- Pedersen CA, Schneider PJ, Scheckelhoff DJ. ASHP national survey of pharmacy practice in hospital settings: dispensing and administration: 2014. *Am J Health Syst Pharm.* 2015;72(13):1119–1137. doi: 10.2146/ajhp150032.
- Kohn LT, Corrigan JM, Donaldson MS. To Err Is Human [Internet] [cited 2000]. Available from: <http://www.nap.edu/catalog/9728>.
- Popovich D. 30-Second Head-to-Toe Tool in Pediatric Nursing: Cultivating Safety in Handoff Communication. *Pediatr Nurs.* 2011;37:55–59.
- Nuckols TK, Smith-Spangler C, Morton SC, Asch SM, Patel VM, Anderson LJ, et al. The effectiveness of computerized order entry at reducing preventable adverse drug events and medication errors in hospital settings: a systematic review and meta-analysis. *Syst Rev.* 2014;3:56.
- Joint Commission International Accreditation Standards for Hospitals. The Joint Commission. 2014:23.
- Khammarnia M, Kassani A, Eslahi M. The Efficacy of Patients' Wristband Bar-code on Prevention of Medical Errors: A Meta-analysis Study. *Appl Clin Inform.* 2015;6:716–727.
- Brailer D. The decade of health information technology, Framework for Strategic Action [Internet] [cited 2004]. Available from: http://www.providersedge.com/ehdocs/ehr_articles/the_decade_of_hit-delivering_customer-centric_and_info-rich_hc.pdf.
- van Wyk JT, van Wijk MAM, Sturkenboom MCJM, Mosseveld M, Moorman PW, van der Lei J. Electronic alerts versus on-demand decision support to improve dyslipidemia treatment: a cluster randomized controlled trial. *Circulation.* 2008;117:371–378.
- Leung AA, Denham CR, Gandhi TK, Bane A, Churchill WW, Bates DW, et al. A safe practice standard for barcode technology. *J Patient Saf.* 2015;11:89–99.
- Roshanov PS, Fernandes N, Wilczynski JM, Hemens BJ, You JJ, Handler SM, et al. Features of effective computerised clinical decision support systems: meta-regression of 162 randomised trials. *BMJ.* 2013;346:f657.
- Clinical Decision Support (CDS) [Internet] Office of the National Coordinator for Health Information Technology. Available from: <https://www.healthit.gov/policy-researchers-implementers/clinical-decision-support-cds>.
- Strom BL, Schinnar R, Abera F, Bilker W, Hennessy S, Leonard CE, et al. Unintended effects of a computerized physician order entry nearly hard-stop alert to prevent a drug interaction: a randomized controlled trial. *Arch Intern Med.* 2010;170:1578–1583.
- Dainty KN, Adhikari NKJ, Kiss A, Quan S, Zwarenstein M. Electronic prescribing in an ambulatory care setting: a cluster randomized trial. *J Eval Clin Pract.* 2012;18:761–767.
- Davis J, Riesenber LA, Mardis M, Donnelly J, Benningfield B, Youngstrom M, et al. Evaluating outcomes of electronic tools supporting physician shift-to-shift handoffs: A Systematic Review. *J Grad Med Educ.* 2015;7:174–180.
- Kaushal R, Kern LM, Barron Y, Quaresimo J, Abramson EL. Electronic prescribing improves medication safety in community-based office practices. *J Gen Intern Med.* 2010;25:530–536.
- Patient Safety Dictionary [Internet] National Patient Safety Foundation. [Update 2017; Accessed 2017 September].
- Shojania KG, Jennings A, Mayhew A, Ramsay CR, Eccles MP, Grimshaw J. The effects of on-screen, point of care computer reminders on processes and outcomes of care. *Cochrane Database Syst Rev.* 2009;3:CD001096.
- Computerized Provider Order Entry [Internet] Agency for Healthcare Quality & Research.

- Saleh Hamad Al Kulayb, Yahya Hamad Alyami, Abdaullah Hamad Alyami, Essa Yahya Aldashl, Hussin Mahdi Hussin Al Salem, Hadi Munassir Hezam Alyami, Abdullah Hassan Motlk Alwayili, Mohammed Munasser Hazam Alyami, Saleh Hamad Saleh Al Hannan, Abdullah Saeed Ali Althaiban, Mulfi Mohammed Hezam Alyami [cited 2017].
- Shah NR, Seger AC, Seger DL, Fiskio JM, Kuperman GJ, Blumenfeld B, et al. Improving acceptance of computerized prescribing alerts in ambulatory care. *J Am Med Inform Assoc.* 2006;13:5–11.
- Paterno MD, Maviglia SM, Gorman PN, Seger DL, Yoshida E, Seger AC, et al. Tiering drug-drug interaction alerts by severity increases compliance rates. *J Am Med Inform Assoc.* 2009;16:40–46.
- Devine EB, Hansen RN, Wilson-Norton JL, Lawless NM, Fisk AW, Blough DK, et al. The impact of computerized provider order entry on medication errors in a multi specialty group practice. *J Am Med Inform Assoc.* 2010;17:78–84.
- Li P, Ali S, Tang C, Ghali WA, Stelfox HT. Review of computerized physician handoff tools for improving the quality of patient care. *J Hosp Med.* 2013;8:456–463.
- Crossing the Quality Chasm [Internet] [cited 2001]. Available from: <http://www.nap.edu/catalog/10027>.
- Kew KM, Cates CJ. Home telemonitoring and remote feedback between clinic visits for asthma. *Cochrane Database Syst Rev.* 2016;8:CD011714.
- Rothschild JM, Keohane CA, Cook EF, Orav EJ, Burdick E, Thompson S, et al. A controlled trial of smart infusion pumps to improve medication safety in critically ill patients. *Crit Care Med.* 2005;33:533–540.
- Nagykaldi Z, Aspy CB, Chou A, Mold JW. Impact of a Wellness Portal on the delivery of patient-centered preventive care. *J Am Board Fam Med.* 2012;25:158–167.
- Kew KM, Cates CJ. Remote versus face-to-face check-ups for asthma. *Cochrane Database Syst Rev.* 2016;4:CD011715.
- Fiks AG, Mayne SL, Karavite DJ, Suh A, O'Hara R, Localio AR, et al. Parent-reported outcomes of a shared decision-making portal in asthma: a practice-based RCT. *Pediatrics.* 2015;135:e965–e973.
- Chapuis C, Roustit M, Bal G, Schwebel C, Pansu P, David-Tchouda S, et al. Automated drug dispensing system reduces medication errors in an intensive care setting. *Crit Care Med.* 2010;38:2275–2281.
- Olayiwola JN, Anderson D, Jepeal N, Aseltine R, Pickett C, Yan J, et al. Electronic consultations to improve the primary care-specialty care interface for cardiology in the medically underserved: a cluster-randomized controlled trial. *Ann Fam Med.* 2016;14:133–140.