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Systematic Review

The Effect of Health Information Technology on Patient Safety and Clinical Outcomes: A Systematic Literature Review

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Abstract

Background: Healthcare systems face significant challenges related to medical errors and adverse events. Health information technology (HIT) offers potential solutions by improving healthcare systems. This study investigated the impact of HIT on patient safety, addressing challenges associated with medical errors and adverse events.

Methods: A comprehensive literature review was conducted using scientific databases up to September 2020. A total of 138 articles were retrieved, of which 38 aligned with the study's objectives. HIT aspects analyzed included radio frequency identification (RFID), computerized physician order entry (CPOE), clinical decision support system (CDSS), health information system (HIS), information technology (IT), and electronic health record (EHR). The study examined HIT's influence on patient safety factors such as medical-pharmaceutical errors, the care process, care volume and workflow, quality of care, side effects, and readmissions. A data collection form was designed for electronic data extraction, capturing key information. Extracted data were then analyzed and reported accordingly.

Results: Regardless of HIT type, 29% of studies reported positive impacts, 31.6% somewhat positive, 36.8% required further investigation, and 2.6% with no positive effect on patient safety. Positive studies highlighted benefits such as reduced medication errors, improved diagnostics, accelerated services, error reduction, and enhanced patient safety. However, studies with negative findings cited drawbacks, including patient misidentification, inaccurate drug dosage calculations, partial information access, system dependence, and high implementation costs.

Conclusion: Overall, HIT interventions are beneficial. However, given their broad scope, focused studies on individual technologies are necessary to facilitate more in-depth analysis and evaluation.

Keywords: Health information technology, Patient safety, Clinical outcomes, Review

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Introduction

Ensuring patient safety is a paramount aspect of delivering quality healthcare. Any harm resulting from healthcare services and medical errors contradicts the fundamental philosophy of healthcare. Patient safety aims to prevent harm and errors during care provision; however, medical procedures and interventions are not always risk-free. Medical errors, particularly medication-related mistakes, remain a persistent threat to patient safety within healthcare systems, frequently occurring in hospitals and health centers worldwide (1).

Research across the globe highlights that medical errors and adverse events pose significant challenges within healthcare systems, raising international concerns. Unlike errors in other industries, medical errors impact not only patients but also the entire healthcare system, often leading to widespread consequences. The complex nature of healthcare systems, with numerous interconnected

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components, facilitates the transmission of errors throughout the system. Studies such as those conducted by the Star Field Institute and the American Institute of Medicine (IOM) reveal that medical errors in the United States contribute to a substantial number of annual deaths, making them the third leading cause of mortality (2).

Medical errors remain a significant global issue, as evidenced by data from the Agency for Healthcare Research and Quality (AHRQ). With an estimated 1 million medical errors occurring annually, addressing these challenges and enhancing patient safety is crucial (3). Medication errors, in particular, contribute to a substantial number of adverse events and fatalities. Various studies conducted in different countries highlight the extent of medical errors and their impact on patients. In the United States, these errors account for a notable percentage of deaths and rank among the leading causes of mortality. Lawsuits and complaints related to medication errors further underscore the severity of this issue. Research in Canada and Australia has also identified significant rates of medical errors, with common errors including care team communication failures, postoperative care, and diagnostic inaccuracies. In Iran, drug interactions are a major concern, highlighting the need for improvements in prescription practices (2).

Health Information Technology (HIT) has emerged as a promising solution to these challenges, revolutionizing healthcare organizations, professional practices, and patient management over the past 25 years (4). As a recommended strategy by healthcare industry pioneers, leveraging technology can enhance healthcare quality, prevent medical errors, and improve overall patient health outcomes. HIT encompasses various tools, from simple charts to advanced decision support systems, offering numerous benefits such as reducing human errors, improving clinical outcomes, enhancing care coordination, and increasing operational efficiency. It plays a crucial role in enhancing patient safety by minimizing medication errors, reducing adverse drug reactions, and ensuring adherence to clinical guidelines (5-14).

Existing research has explored the impact of specific aspects of HIT on patient safety, often focusing on only one or two components (6). Comprehensive reviews examining multiple HIT aspects and their collective influence on patient safety remain limited (15). This study aimed to address this gap by reviewing and analyzing various HIT interventions, including computerized medical order entry, decision support systems, barcode technology, mobile health, electronic health records, electronic prescribing, electronic medication management systems, telemedicine, nursing information systems, patient safety information systems, and radio frequency identification (RFID) technology. Through this comprehensive examination, the study sought to identify both the positive and negative effects of these HIT interventions on patient safety and healthcare outcomes.

Materials and Methods

This is a systematic review of studies assessing HIT's impact on patient safety and healthcare outcomes up to 2021. No sampling was applied. A data extraction form was used to gather relevant study details, and descriptive statistical analysis was performed using Excel. This comprehensive approach ensures a thorough evaluation of HIT's influence on patient safety across various contexts.

Inclusion and Exclusion Criteria

This systematic review assessed studies evaluating the impact of HIT on patient safety and healthcare outcomes. HIT aspects included electronic prescribing, RFID, mobile health-based medication management, computerized physician order entry (CPOE), clinical decision support system (CDSS), health information systems and technologies (HIS and IT), patient safety information systems, electronic health record (EHR), and clinical and nursing information systems. Patient safety and healthcare outcomes included the reduction of medical-pharmaceutical errors, improvement of care process, improvement of volume and workflow, improvement of care quality, reduction of side effects, and reduction in readmissions. As a result, the inclusion criteria included studies that examined one aspect of HIT and one aspect of patient safety or clinical care outcomes. Studies were also included if they were published in Persian or English. Narrative reviews were excluded from the study.

Search Strategy

Two researchers independently conducted a comprehensive database search to collect relevant data until 2021. Scientific databases, including PubMed, Scopus, Web of Science (Clarivate Analytics), Cochrane, ScienceDirect, SID, Magiran, Irandoc, and *Regional Information Center for Science and Technology (RICeST)*, were explored for studies on HIT and patient safety. MeSH terminology in PubMed was utilized to develop the search strategy, incorporating synonyms and related terms for both HIT (e.g., health informatics, medical informatics, and clinical informatics) and patient safety (e.g., patient safeties, safety, and patient).

Data Extraction

A data collection form was designed to electronically extract relevant information from selected studies. The extracted data included title, author, publication year, journal, study type, population, sample, instruments, objectives, key findings, and conclusions.

Data Analysis

This study considered six key aspects of patient safety: reduction of medical-pharmaceutical errors, improvement of the care process, enhancement of volume and workflow, improvement of care quality, reduction of side effects, and decrease in readmissions. Additionally,

the impact of HIT on patient safety was classified into four groups: positive impact (Studies reporting over 70% positive effects), somewhat positive impact (Studies indicating a 50 to 70% positive effect), needs further investigation (Studies reporting a 20 to 49% positive effect), not purely positive impact (Studies with less than 20% positive effect or no effect). The full text of the articles was reviewed, and based on their findings, the impact of HIT on safety and patient care outcomes was classified into the aforementioned categories. An attempt was made to incorporate the PRISMA method in the study design.

Results

This study aimed to investigate the impact of HIT on patient safety and clinical outcomes. To achieve this, relevant studies and articles were reviewed, and the findings were presented in four tables and one figure. Table 1 presents the frequency distribution of studies across various scientific databases.

The status of the reviewed articles is illustrated in Figure 1.

Among the studies collected from the databases, 16 were systematic reviews, 14 were cross-sectional descriptive research studies, 2 were field analysis studies (interviews), 2 were cross-sectional studies (randomized controlled), 3 were analytical studies, and 1 was quasi-experimental. The highest frequency was observed in systematic review studies (42.2%), while the lowest frequency was found in quasi-experimental studies (2.6%). Regarding the research population in the studies: 16 cases (42.1%) focused on articles, 4 cases (10.5%) on therapists, 13 cases (34.2%) on various technologies and health information systems, and 5 cases (13.2%) on patients.

In terms of publication period, 6 studies were conducted before 2010, whereas 32 studies were published from 2010 onwards, with the highest frequency of studies occurring after 2010. Additionally, 7 studies were from Iran, while 31 studies were from outside Iran, with foreign studies representing the highest frequency (81.6%) among the studies. The frequency distribution of studies according to HIT type is shown in Table 2.

The content and purpose of the studies are divided into several categories according to the technology studied (Table 2), with 11 studies (28.9%) investigating the impact of EHR technology on patient safety, making it the most frequent in terms of content and purpose among the studies. Other studies, in terms of frequency of content and purpose, were as follows: 3 studies (7.9%) investigated the impact of CPOE technology on patient safety, 8 studies (21.1%) examined the impact of CDSS technology, 1 study (2.6%) analyzed the impact of RFID technology, 1 study (2.6%) examined the impact of Barcode technology on patient safety, 13 studies (34.3%) explored the impact of information systems (IT), and 1 study (2.6%) examined the impact of Telemedicine technology.

Patient safety and clinical outcomes in this study were considered in sex categories, including the reduction of medical-pharmaceutical errors, improvement of the care process, improvement of volume and workflow, improvement of the quality of care, reduction of side effects, and reduction of readmissions (Table 3).

The status of HIT's impact on patient safety was considered in four groups: Positive impact, somewhat positive impact, needs further investigation, and not purely positive impact. Table 4 depicts the frequency distribution of studies based on their impact on patient safety.

Discussion

This systematic review examined the relationship between HIT and patient care outcomes, with a focus on patient safety. The findings indicate that most studies (81.6%) were derived from foreign databases conducted after 2010. This trend highlights the importance of HIT's impact on patient safety in advanced healthcare environments in developed countries. However, the limited number of domestic studies, primarily consisting of systematic reviews, suggests that new technologies may not yet be widely adopted in Iranian healthcare centers or are not currently a significant concern for local healthcare officials.

Impact of Electronic Health Record Technology

Among the studies examining the effect of EHR technology on patient safety, 27.3% reported positive or somewhat positive impacts (7,13,16), while 9.1% found no positive impact (17). The remaining 63.6% suggested further investigation (18-24). Studies reporting a positive impact highlighted improvements in diagnostic

Table 1. Distribution of Frequency of Studies According to the Scientific Databases

Scientific Databases	Total Number of Articles	Number of Unrelated Cases	Number of Related Cases	Number of Similar Cases	Related Articles With Target Similar Articles	Percentage of Related Articles Without Similarity
PubMed	55	29	26	6	20	52.6
Cochrane	16	9	7	3	4	10.5
ScienceDirect	29	19	10	3	9	18.5
Magiran	9	5	4	3	1	2.6
SID	10	4	6	2	4	10.5
RICeST	19	13	6	4	2	5.2
Total	**138**	**79**	**59**	**21**	**38**	**100**

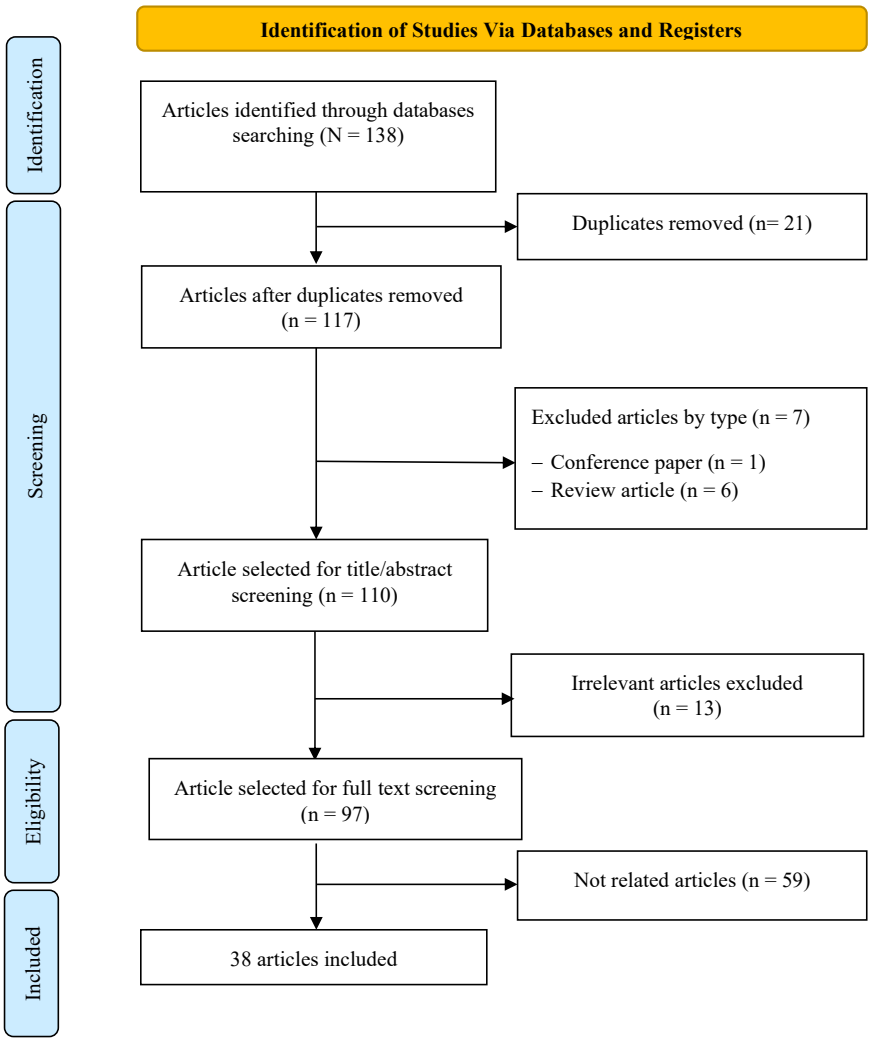

Figure 1. Article Screening and Reviewing Process

Table 2. Frequency Distribution of Studies According to HIT Type

HIT Type	CDSS	Tele-Medicine	EHR	IT/IS	CPOE	RFID	Barcode	Total
Number	8	1	11	13	3	1	1	38
Percent	21.1	2.6	28.9	34.3	7.9	2.6	2.6	100

Note. HIT: Health information technology; IT: Information technology; IS: Information system; EHR: Electronic health record; CPOE: Computerized physician order entry; CDSS: Clinical decision support system; RFID: Radio-frequency identification.

Table 3. Frequency Distribution of Studies Based on Different Aspects of Patient Safety

	Different Aspects of Patient Safety						Total
	Reduction of Medical-Pharmaceutical Errors	Improvement of Care Process	Improvement of Volume and Workflow	Improvement of Care Quality	Reduction of Side Effects	Reduction of Readmissions	
Number	14	9	5	8	1	1	38
Percent	36.8	23.7	13.2	21.1	2.6	2.6	100

Table 4. Frequency Distribution of Studies Based on Impact on Patient Safety

	Status of HIT Impact on Patient Safety				Total
	Positive Impact	Somewhat Positive Impact	Needs Further Investigation	Not Purely Positive Impact	
Number	11	12	14	1	38
Percent	29.0	31.6	36.8	2.6	100

processes, enhanced drug therapy management, reduced adverse safety events, and lowered healthcare costs (7,13,16). Conversely, studies noting negative or neutral impacts reported issues such as the unavailability of medical documentation, incorrect patient identification, inaccurate drug dose calculations, and limited access to patient medication information (17). Consequently, researchers recommend implementing more transparent and informative EHR systems, focusing on qualitative improvements and redesigning existing systems to enhance patient safety and reduce medication errors. The coordination and exchange of health information among healthcare stakeholders play an important role in improving healthcare quality and safety while reducing costs. EHR systems and health information exchange platforms provide an opportunity to facilitate optimal clinical decision-making and increase patient safety. Moreover, unintended consequences, including diagnostic errors that may lead to patient death and endanger patient safety, can be controlled by implementing EHR systems, facilitating diagnosis, and improving the diagnostic process, as well as improving patient safety (7).

Impact of Computerized Physician Order Entry Technology

Among studies assessing the effect of CPOE technology on patient safety, 66.7% reported positive impacts (25,26), while one study recommended further investigation (1). The studies highlighting positive impact reported improvements in care quality, patient safety, cost-effectiveness, therapist knowledge, medication management, and reduced medication errors (25,26). Researchers suggest integrating CPOE with CDSS to further minimize medical and medication errors. The CPOE system combined with CDSS can generate reminders as physicians enter orders, providing help in critical aspects such as drug interactions, interactions between specific medications, drug prescriptions that need to be changed based on laboratory test results, allergies, and potentially toxic conditions requiring attention (5). According to an estimate made in the United States, if effective CPOE is implemented comprehensively in all hospitals in the United States, this system will prevent approximately 567 000 serious and high-severity errors annually. If only 1% of these errors are fatal, then approximately 6000 deaths will be saved annually by implementing CPOE (1). However, further evidence is needed to fully understand CPOE's overall impact, as some studies have cited system dependence and reduced communication between healthcare providers as potential drawbacks (1).

Impact of Clinical Decision Support Systems Technology

Among the studies assessing the impact of CDSS technology on patient safety, 87.5% reported positive or somewhat positive effects. Researchers found improvements in patient safety, workflow, communication, and overall care quality through CDSS implementation (3,27-32). Integrating CDSS with CPOE technology has been suggested to further reduce medical and medication errors. The use of CDSS across five functional areas, disease flow management, care and treatment, medication prescription, and evaluation and prevention, has demonstrated a significant impact on improving the care process and enhancing the performance of healthcare providers, ultimately contributing to improvements in care quality and increased patient safety by reducing medication errors and subsequent drug complications (6).

Impact of Radio Frequency Identification and Barcode Technology

A study on RFID technology called for further investigation into its impact on patient safety (33). While researchers acknowledged several positive aspects, including faster healthcare services, error reduction, patient identification monitoring, and cost savings, they also noted drawbacks such as high implementation costs, reduced security and privacy, and time-consuming implementation. Given these mixed findings, further studies in different environments are recommended.

The single study on Barcode technology reported a positive effect on patient safety, with researchers attributing significant improvements in medication error reduction and inpatient care to the implementation of this technology (34). They recommend the adoption of Barcode technology to enhance patient safety. One of the most effective technologies for managing and executing medication orders, thereby ensuring medication safety, is the barcode medication management system. When used correctly, this system can significantly reduce medication error rates. One of the most common medical errors arises from paper prescriptions where poor handwriting by doctors, endangers patient safety and increases the likelihood of medical errors. Implementing an electronic prescribing system can improve numerous problems of paper prescribing and reduce prescribing errors, medication errors, and adverse drug reactions while improving drug therapy and patient safety (9).

Impact of Telemedicine and Information Systems Technology

A study evaluating the impact of Telemedicine technology on patient safety found a somewhat positive effect (35). Researchers concluded that Telemedicine is cost-effective, sustainable, simple, and inexpensive for patient management, while also increasing care quality. Among the studies examining the effect of Information Systems technology on patient safety, 30.8% reported positive impacts (14,36-38), 30.8% found somewhat positive impacts (39-42), and 38.4% called for further investigation (22,43-46). Overall, 61.6% of studies reported positive

or somewhat positive effects. Studies reporting positive impacts observed reductions in the time required to complete electronic records, decreased medication errors, and improvements in patient safety and care quality (14,36-38). Conversely, studies advocating for further investigation highlighted limited physician access to information as a significant challenge, suggesting the need for system modifications to improve effectiveness (22,43-46).

Conclusion

This study found that 29% of studies demonstrated positive impacts of HIT on patient safety, while 31.6% indicated somewhat positive effects, 36.8% called for further investigation, and 2.6% found no positive impact. Studies with positive outcomes highlighted several benefits such as reduced medication errors, improved diagnostics, accelerated services, error reduction, and enhanced patient safety. However, studies reporting negative findings identified drawbacks, including incorrect patient identification, inaccurate drug dose calculations, partial information access, system dependence, and high implementation costs. Since roughly 60% of studies indicated positive effects or somewhat positive effects, HIT can be considered beneficial for improving patient safety. However, given that 39.4% of studies called for further investigation or noted no positive impact, addressing technology limitations, enhancing system features, and reducing associated risks is necessary. To accomplish this, further research focusing on individual technologies is recommended to facilitate a more detailed analysis.

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Competing Interests

The authors declare no conflict of interests.

Ethical Approval

This study was approved by the Ethics Committee of Hamadan University of Medical Sciences under the Code of Ethics: IR.UMSHA.REC.1399.848.

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