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REVIEW ARTICLE

HOSPITAL ELECTRONIC PRESCRIBING: A SYSTEMATIC REVIEW OF ITS IMPACT ON MEDICATION ERRORS AND PHARMACEUTICAL SERVICES

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ABSTRACT

E-prescribing is a strategy healthcare providers use to improve pharmacy services and reduce medication errors. This systematic review aimed to evaluate the impact of an electronic prescribing strategy on improving pharmacy services and reducing medication errors in hospitals. A comprehensive search was conducted in December 2023 to identify e-prescribing in hospitals. A literature search in the MEDLINE, Science Direct, and Cochrane electronic databases identified 962 articles. Ten articles met the eligibility criteria for inclusion in this review.

The findings of this review highlight the potential of automated detection systems in identifying potentially dangerous wrong-drug errors. These errors, often difficult to detect using traditional reporting and surveillance methods, can be more readily identified through automated tools.

Additionally, the hybrid decision support algorithm can assist clinical pharmacists in prioritizing prescribing checks, reducing the risk of medication errors, and improving overall pharmacy efficiency. This leads to several benefits, including faster prescribing reception, improved drug compliance, enhanced rectification of wrong prescribing, reduced healthcare costs, improved service quality, and decreased malpractice claims. Implementing electronic prescribing systems for healthcare providers could improve communication between prescribers and pharmacists, leading to more efficient and effective medication management.

KEY WORDS: E-Prescribing; Hospital; Medication errors; Pharmacy services.

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INTRODUCTION

Despite their crucial role in managing illnesses, medications can lead to life-threatening situations if used incorrectly. These unintentional and avoidable medication errors, classified as drug-induced harm, warrant serious attention. Medication errors pose a significant threat to public health in the US, causing an estimated 7,000 - 9,000 deaths annually. Additionally, hundreds of thousands of patients experience adverse drug reactions and complications, a concern that may be underestimated due to underreporting. The total annual cost of treating patients with treatment-related errors exceeds $40 billion annually.[1] Compared to electronic prescribing, traditional handwritten prescribing are prone to a higher risk of errors due to several factors, including incomplete information, illegible handwriting, and difficulty in processing intricate patient data.[2-5] Hospitals have implemented strategies to minimize the incidence of medication errors and improve pharmacy services, particularly prescribing services. One of the methods used is an electronic prescribing system. E-prescribing involves writing prescribing through an automated data entry process using specific software and an Internet network connected to a hospital pharmacy. The electronic prescribing initiative involved either a stand-alone Computerized Clinical Decision Support System or a Computerized Physician Order

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Entry system, with the latter potentially including an integrated clinical decision support component.[6-8]

The electronic prescribing system at the hospital has many advantages, namely the improvement of pharmaceutical services such as fast data entry and reduced waiting time for patients to receive drugs.[4,9,10] Patient services can be carried out quickly, accurately, and transparently, thereby providing patient satisfaction. The electronic perception system can also reduce the incidence of medication errors, such as avoiding the risk of misinterpretation, reducing the occurrence of incorrect drug indications, correct dosage, and proper drug preparation.[3,4] This review article aims to conduct a systematic review to evaluate the impact of an e-prescribing strategy on improving pharmacy services and reducing medication errors in hospitals.

MATERIALS AND METHOD

Search Strategy: A comprehensive search was conducted in December 2023 to identify e-prescribing in hospitals. Full-text studies were eligible studies published in English from January 1, 2017 to December 31, 2023. Using MEDLINE, Science Direct, and Cochrane as information sources, the search identified articles with potential relevance to the topic under study. The leading search was conducted using the terms electronic prescribing, hospital, medication errors, and pharmacy services. The results were limited to the English language. The review was then carried out according to the PRISMA guidelines.[11] To ensure a comprehensive search, we used something other than digital tools. To increase the number of articles, we manually reviewed the bibliographies of certain publications. Figure 1 outlines the complete search strategy, including the specific terms used.

Eligibility criteria: All the studies that investigated the implementation of electronic prescribing were included. Studies must have been conducted in hospitals and published in English between January 2017 and December 2023. The reported results must consist of at least one medication error or improvement in pharmacy services. We excluded studies that implemented electronic prescribing in community health centers and those that only included inpatients. We excluded conference papers, reviews, editorials, and opinion pieces.[11]

Study Selection: A literature search of MEDLINE, Cochrane, and Science Direct identified 962 articles. An additional search was performed to increase the number of articles and get one more article. Some articles were excluded for several reasons. Three articles were excluded as they were not written in English. Twenty-six articles were excluded because their type included literature reviews, opinions, letters, and comments. Eight hundred and seventy-six articles were excluded because they did not examine e-prescribing.

The initial screening of abstracts rendered 73 articles eligible for full-text reviews. Based on the full-text review for eligibility, seven articles could not be accessed for the full text. Fourteen Studies were excluded because they did not report medication errors, 14 studies were not conducted in hospitals, and 28 studies used only inpatient samples. Ten articles met the eligibility criteria for this review (Figure 1).

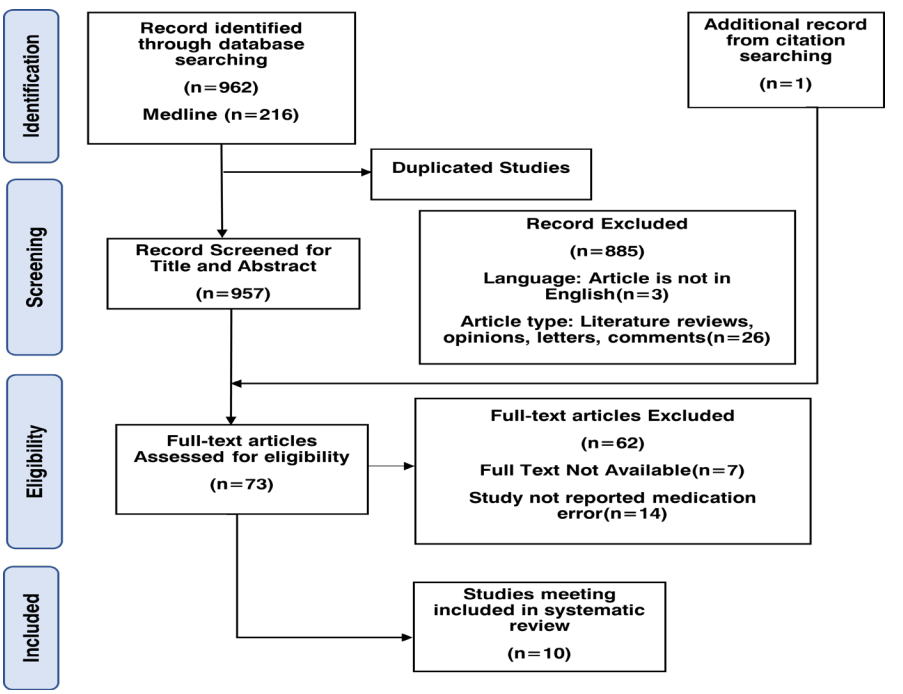

Figure 1. PRISMA study flow diagram

Characteristics of included studies: Detailed information regarding the study characteristics is provided in Table 1. Studies were published between 2017 and 2023. Two were conducted in France and the United Kingdom, and one was conducted in Egypt, China, Ethiopia, the US, Indonesia, and Brazil. The type of electronic prescribing strategies used was four studies using Computerized Physician Order Entry (CPOE) and seven studies using Computerized Decision Support System (CDSS).

RESULT

Outcomes Evaluated:

Four studies reported the impact of electronic prescribing on medication errors, three studies reported the impact on pharmacy services, and four studies reported both. Table 1 summarizes the studies showing improved outcomes (medication error and Pharmacy Services) according to electronic intervention type.

Medication Error:

Across studies, the concept of medication error encompasses a wide range of issues, including missing information on prescribing, prescribing adjustments, incorrect dosing schedules, drug interaction concerns, inaccuracies in copying or handling medications, and mistakes during dispensing, administering, and monitoring. Results from several studies[3,4,10,12] Show that electronic prescribing demonstrably reduces medication errors during both prescribing and dispensing. Its full potential for error prevention may require integration with advanced decision support features to address the dramatically different types of errors.

Electronic prescribing systems in hospitals now use error prevention detection systems, such as those proposed by Lambert et al.[13] One study successfully tested an automated system for catching "look-alike/sound-alike" medication errors, even those missed by other methods. However, the system's accuracy depends on drug name similarity and shared administration routes.[13] This study demonstrated the potential of automated detection as a valuable trigger tool for identifying wrong-drug errors, a relatively uncommon yet challenging category missed by current reporting and surveillance approaches.[13] Corny et al.[14] presented a novel hybrid decision support algorithm that effectively identifies high-risk medication errors in prescribing, regardless of the prescribing method. Compared to traditional CDS systems and multicriteria queries, this algorithm exhibits superior accuracy in detecting errors while minimizing false alerts.[14]

Electronic Prescribing Systems (EPS) offer significant potential to reduce medication errors through multiple interconnected mechanisms. Fundamentally, they enhance the organization and readability of prescribings, mitigating errors stemming from illegible handwriting or confusingly similar drug names.[3,4,9,10] Furthermore, EPS promotes standardization by providing consistent formats for prescribings, which minimizes interpretation errors and reduces mistakes related to ambiguous drug descriptions.[15]

The effectiveness of these systems is significantly bolstered by proper parameterization, such as ensuring that complete drug descriptions are mandatory. This specific configuration has been shown to lead to a statistically significant decline in both the overall frequency and specific types of prescribing errors.[12] Crucially, EPS actively helps prevent dangerous practices like the use of illegible entries, hazardous abbreviations, and incorrect pharmaceutical forms by incorporating standardized items and enforcing restrictions on certain prescribing elements.[16] Collectively, these functionalities contribute to the primary goal of enhanced patient safety, as studies demonstrate that EPS implementation can improve patient health by reducing the frequency of prescribing errors and preventing related incidents and adverse events.[15]

Pharmacy Services:

Artawan et al.[3] described and analysed the implementation of e-prescribing in Sanglah Hospital, Denpasar, Indonesia. A hospital information system enables the electronic flow of data from a hospital, allowing for faster, more accurate, and transparent patient services. Changes in pharmacy services have also been reported by other studies. A clinical pharmacist reviews alerts generated by the CDSS and recommends medication interventions to physicians only for relevant alerts. Once implemented, these interventions have a two-thirds acceptance rate.[6]

Despite raising concerns about new risks associated with e-prescribing, such as alert fatigue, the analysis acknowledges its potential advantages, including reduced prescribing errors due to improved legibility, simplified access to repeat prescriptions, and enhanced tracking functionalities.[17] Although there is a lack of concrete data on the effectiveness of electronic prescribing, Jia et al.[17] urged careful risk assessment to ensure that it enhances patient safety by minimizing existing clinical risks and managing potential hazards brought on by this new technology.[17]

These benefits could indirectly impact pharmacy services by improving medication safety and reducing the workload for correcting medication errors. Additionally, implementing electronic prescribing systems could potentially improve the communication between prescribers and pharmacists, leading to more efficient and effective medication management.

Table 1 Included Studies (n =10) by Design Type and Year of Publication

Author Year Country	Electronic Strategy	Setting	Study Design	Outcome	
				Medication Error	Improving Pharmacy Services
Kenawi et al. (2019)[4] Egypt	Computerized Physician Order Entry (CPOE)	outpatient clinic of a specialized hospital	Retrospective observational study	Significant Safety Gains: 2% Fewer Prescribing Errors, 1.2% Less in Dispensing	-
Yang et al. (2019)[10] China	Computerized Physician Order Entry (CPOE)	tertiary-care teaching hospital	Cross-sectional study	0.34% of prescribings had errors. Of these errors, 13.62% were severe.	The study found no statistically significant association between the number of prescribings written and the rate of medication errors.
Lambert et al. (2019)[13] US	Computerized Decision Support System (CDSS)	University Hospital	Retrospective observational design	This study demonstrates the successful implementation of automated detection for LASA medication errors, highlighting its potential to identify previously missed errors through other methods.	-
Jia et al. (2019)[17] UK	Computerized Physician Order Entry (CPOE)	three teaching hospitals	Report Case Study	-	reduction in prescribing errors due to fewer illegible orders, more accessible repeat prescribings, and better ability to track prescribings
Rosa et al. (2019)[15] Brazil	Computerized Decision Support System (CDSS)	two public teaching hospitals	An experimental two-stage retrospective study	The findings from the study indicated that the impact of EPS on medication errors varied between the two hospitals involved in the study. Hospital 1 experienced an increase in the frequency of errors after the implementation of EPS, while Hospital 2 observed a significant decrease in error frequency	-
Artawan et al. (2020)[3] Indonesia	Computerized Decision Support System (CDSS)	Pharmacy Installation	a qualitative and descriptive study	decrease in the incompleteness of writing	E-prescribing can also improve pharmacy efficiency, speed up prescribing reception, promote drug compliance, rectify the wrong prescribing, prevent risks to the danger of health costs, improve service quality, and reduce malpractice claims.
Corny et al. (2020)[14] France	Computerized Decision Support System (CDSS)	a single hospital setting	Retrospective observational study	Research has shown that the hybrid decision support algorithm effectively identifies and flags high-risk prescribing orders for potential medication errors, irrespective of the prescribing method employed.	The hybrid decision support algorithm can help clinical pharmacists prioritize prescribing checks and reduce the risk of medication errors in healthcare settings.
Alshahrani et al. (2021)[18] UK	Computerized Physician Order Entry (CPOE)	Academic tertiary care hospital	Qualitative design	While offering potential benefits, electronic prescribing systems (CPOE) can also introduce new avenues for medication errors through factors like misselected drug names, automated dosage defaults, alert overload, and the complexities of remote prescribing.	-
Teferi et al.(2022)[19] Ethiopia	Computerized Decision Support System (CDSS)	Public hospitals	cross-sectional study	-	Implementing electronic prescribing systems could improve communication between prescribers and pharmacists, leading to more efficient and effective medication management.
Romaric et al. (2023)[16] France	Computerized Decision Support System (CDSS)	University Hospital	Mixed-methods approach	The study revealed limitations in the CDSS's user interface, including unclear layouts, inconsistencies in display elements, and cumbersome filter functionalities. These usability issues could hinder the system's efficacy in preventing medication errors.	CDSS was perceived as beneficial by clinical pharmacists, as it helped them become aware of iatrogenic risks and learn how to prevent or manage them

DISCUSSION

This review focuses on determining whether the application of electronic prescribing reduces medication errors. Electronic systems have eliminated specific errors, such as sloppy handwriting, and legal aspects of prescribings, such as patient details.[3,4] While the implemented system modestly reduced dispensing and prescribing errors, it remains limited in addressing other types of errors, particularly drug-drug interactions. Additionally, its impact on pharmaceutical workflows varies across settings. The study's findings are still pending completion, as it focused on errors captured by the existing error form, excluding factors such as under-prescribing, over-prescribing, and misdiagnosis.

Electronic prescribing (e-prescribing) uses electronic systems to create, transmit, and receive medication. This can potentially improve medication safety by reducing medication errors, improving communication between healthcare providers, and increasing patient compliance. There is a growing body of evidence supporting the benefits of e-prescribing. For example, Kenawy et al.[4] found that e-prescribing significantly reduced medication errors in an Egyptian hospital setting. The study also found that e-prescribing improved communication between pharmacists and prescribers and increased patient compliance with medication regimens.

Although e-prescribing promises excellent medication safety in hospitals, its implementation is challenging. As Artawan et al.[3] As highlighted, the system can be difficult to adopt and use, even leading to the introduction of new error types. Their study emphasized the crucial role of solid commitment from institutions and healthcare providers for successful implementation. A deeper exploration of these complex challenges reveals six essential themes: the inherent capabilities and limitations of the system; the prescriber's training, expertise, and potential biases; the patient's involvement and health literacy; the communication and collaboration within the healthcare team; the specific demands and intricacies of the prescribing task; and the surrounding pressures and constraints of the work environment. Each element can introduce vulnerabilities, such as system errors in drug selection, dosage defaults, overused alerts, and remote prescribing complexities. These factors intertwine within the intricate web of the prescribing process, making the causes of electronic prescribing errors multifaceted.

The implementation of the electronic prescribing system in hospitals presents several significant challenges beyond initial adoption. A primary hurdle is ensuring seamless integration with existing hospital technologies and clinical workflows; without careful planning and execution, new systems can disrupt efficiency and practicality.[20]through the analysis of patient safety incident reports. Methods: We analysed 827 voluntarily reported incidents relating to oncology patients that occurred over an 18-month period immediately following implementation of an EMM in a paediatric hospital in Australia. We identified medication-related and EMM-related incidents and carried out a content analysis to identify patterns. Results: We found ~79% (n = 651 Furthermore, while designed to standardize processes, these integrated systems often suffer from reduced customizability. This lack of flexibility can stifle necessary innovation and hinder adaptation to the unique, high-demand requirements of specialized environments like the Intensive Care Unit (ICU). Perhaps most critically, flawed system design choices combined with organizational shortcomings during implementation have been demonstrably linked to adverse events and prescribing errors, highlighting the potential patient safety risks if these systems are not meticulously deployed and managed.[21]

Impact of Electronic Prescribing Systems on Different Hospital Settings.

1. **Large Hospitals (Tertiary-Care and University Hospitals)**

Studies in large hospitals, such as tertiary-care and university hospitals, highlight the scalability and advanced integration of EPS. For instance, Corny et al.[14] in France, a study reported that a hybrid CDSS effectively identified high-risk prescribing errors in a single hospital setting, helping clinical pharmacists prioritize checks. Similarly, Lambert et al.[13] demonstrated successful LASA (Look-Alike, Sound-Alike) error detection with CDSS at a U.S. university hospital, showcasing its capacity to handle complex prescribing environments. These hospitals benefit from robust infrastructure and specialized staff, enabling the better utilization of EPS features, such as advanced algorithms for error prevention and real-time alerts. Large hospitals often face alert fatigue due to high patient volumes and complex prescriptions.[18] Overwhelming notifications may desensitize users, reducing the effectiveness of safety alerts.

2. **Small Hospitals (Specialized and Teaching Hospitals)**

Small hospitals, such as the specialized hospital in Egypt studied by Kenawy and Kett[4], showed modest reductions in prescribing and dispensing errors with CPOE. Similarly, Jia et al.[17] reported fewer illegible prescriptions and improved tracking in three teaching hospitals in the UK, demonstrating the utility of EPS in addressing basic prescribing issues. In smaller settings, EPS is often deployed to reduce human errors due to fewer staff or limited pharmacist oversight. Smaller hospitals may lack advanced CDSS functionalities due to resource constraints, resulting in missed opportunities for detecting complex errors. For instance, Rosa et al.[15] observed mixed results in Brazilian public teaching hospitals, where one

hospital saw increased errors post-implementation due to limited user training and system adaptability.

3. Public Hospitals

Public hospitals, often resource-limited, rely on EPS to improve communication and streamline workflows. Teferi et al.[19] in Ethiopian public hospitals found that CDSS facilitated better collaboration between prescribers and pharmacists, enhancing medication management. The focus in public settings is on reducing basic errors, improving prescription legibility, and enhancing access to medication data, as seen in Artawan and Martini.[3] in Indonesia. Public hospitals often encounter usability issues and limited customization of EPS interfaces, as reported by Marcilly et al.[16] These barriers may limit the system's effectiveness in high-volume public settings.

4. Private Hospitals

Private hospitals may leverage EPS for both clinical and operational advantages, focusing on reducing malpractice risks and enhancing patient safety. However, specific studies focusing solely on private hospitals are limited in the dataset reviewed. These hospitals typically have better resources for training and system customization, which can potentially lead to smoother implementation and greater error reduction. Private hospitals must balance cost efficiency with system effectiveness, ensuring that advanced features, such as predictive analytics and integrated CDSS tools, are financially viable.

The successful implementation of electronic prescribing systems (EPS) in hospitals requires a multifaceted approach that addresses technical, human, and cultural factors. Crucially, system design must be refined to improve user interfaces, minimize default errors, and optimize clinical alert systems to reduce alert fatigue.[22] Concurrently, comprehensive training and ongoing education for prescribers on both the system's functionality and broader medication safety principles are essential.[23] Actively involving clinical pharmacists throughout the design and implementation phases leverages their specialized expertise in medication safety to ensure the system is configured to minimize errors effectively.[8]

Furthermore, fostering a culture of safety that prioritizes open reporting of errors and incidents is paramount, alongside promoting teamwork and communication among all healthcare professionals to collaboratively identify, catch, and learn from potential mistakes.[24] Finally, recognizing that no system is perfect, continuous monitoring for errors and making necessary adjustments based on real-world use and feedback is critical to maintain and enhance the system's safety and effectiveness over time.[6] However, the impact of an electronic prescribing system on medication errors may vary depending on the specific system and its implementation. Poor usability can reduce an EPS's expected acceptability and effectiveness, leading to its underuse and limiting its potential impact on medication errors. Therefore, it is essential to consider the usability and usefulness of EPSs when evaluating their impact on medication errors.

Limitations

This study had several limitations. First, our literature search was limited to articles published in English and indexed in MEDLINE, Science Direct, and the Cochrane Library. Second, computerized interventions that assist in medical prescribing remain heterogeneous, from order entry without decision support to order entry with advanced decision support. These electronic systems vary widely in their prescribing functionality, clinical use, technology development, and target populations. This heterogeneity contributes to caution when interpreting the results. Third, the reported outcomes range from prescribing errors to patient symptoms and side effects.

CONCLUSION

Electronic prescribing systems (EPS) significantly improve medication safety and efficiency in several studies. By reducing human error, standardizing prescribing practices, and enhancing communication between healthcare providers, EPS can help prevent medication errors and improve patient outcomes. However, the successful implementation of EPS requires careful planning, training, and ongoing evaluation. Challenges such as alert fatigue, system usability, and integration with existing workflows must be addressed to maximize the benefits of these systems.

The effectiveness of electronic prescribing systems in reducing medication errors is influenced significantly by hospital type. While large hospitals capitalize on advanced EPS functionalities to address complex prescribing challenges, small and public hospitals often focus on basic error prevention and improving prescription legibility. Private hospitals, with better resources, may achieve higher customization and operational efficiency. The effectiveness of electronic prescribing systems in reducing medication errors is influenced significantly by hospital type. While large hospitals capitalize on advanced EPS functionalities to address complex prescribing challenges, small and public hospitals often focus on basic error prevention and improving prescription legibility. Private hospitals, with better resources, may achieve higher customization and operational efficiency

Recommendation: This study has several implications for healthcare providers and policymakers. This study highlights the importance of implementing electronic prescribing systems among healthcare providers to reduce medication errors and improve patient safety. The study also suggests that ongoing monitoring and optimization of these systems are necessary to ensure that they effectively reduce

errors.

Healthcare providers should also be aware of the types of errors that are likely to occur together and take steps to prevent them. Policymakers may require additional funding and support to expedite the implementation of electronic prescribing systems in hospitals. Policymakers should also consider the potential risks associated with electronic prescribing systems, such as drop-down menu selection errors, and take steps to mitigate these risks. Finally, policymakers should be aware of the types of mistakes that most commonly occur and take steps to address them.

Future research should focus on evaluating the long-term impact of EPS on patient safety, cost-effectiveness, and workflow efficiency. Additionally, studies should explore innovative approaches to address the limitations of current EPS, such as developing more intelligent decision support systems and improving user interfaces. By addressing these challenges and continuing to invest in research and development, we can harness the full potential of electronic prescribing to improve patient safety and healthcare quality.

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CONFLICT OF INTEREST
Authors declare no conflict of interest.
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AUTHORS' CONTRIBUTION

The following authors have made substantial contributions to the manuscript as under:

Conception or Design:	JS, SS
Acquisition, Analysis or Interpretation of Data:	JS, SS, LL, AWW
Manuscript Writing & Approval:	JS, SS, LL, AWW

All the authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.