ORIGINAL ARTICLE

Impact of computerized provider order entry system on medication prescribing errors in hospital wards: a comparative study

Saw Ching Yee, BPharm(Hons), Nadzirah Abdul Kadir, BPharm(Hons), Nagappan N Sekar, MBBS, Joan Wang, BPharm(Hons), Lim Ming Tsuey, BPharm(Hons)

Regency Specialist Hospital, Bandar Seri Alam, Masai, Johor

ABSTRACT

Introduction: Medication errors are a major concern in healthcare, threatening patient safety and increasing costs. These errors can occur at various stages, from prescribing to dispensing and administration. Among these, prescribing errors are particularly critical as they occur at the initial step of medication use process and can propagate downstream, potentially leading to adverse events. Computerized provider order entry (CPOE) systems, with integrated clinical decision support tools offer significant benefits over handwritten prescriptions including enhanced legibility, prescription completeness, standardization, a comprehensive audit trail and real-time alerts and reminders to assist prescribers during the prescribing process. This study aims to evaluate the effectiveness of a CPOE system with clinical decision support features in reducing prescribing errors across the hospital. It compares the rates and error types between electronic and handwritten prescriptions over different time periods following the CPOE implementation.

Materials and Methods: This retrospective comparative analysis examines inpatient prescription data collected from the same hospital wards during three distinct periods: 1st January to 31st March 2023 (59,663 handwritten prescriptions), 1st October to 31st December 2023 (43,363 electronic prescriptions at 3 months post-CPOE implementation) and 1st January to 31st March 2024 (44,317 electronic prescriptions at 6 months post-CPOE implementation). The CPOE system was implemented in July 2023.

Results: The CPOE system significantly reduced medication prescribing errors (3 months post-CPOE: n=832, 1.92%; 6 months post-CPOE: n=617, 1.39%) compared to handwritten prescriptions (n=3532, 5.92%). The odds of errors occurring 3 months and 6 months post-CPOE implementation were 65% and 75% lower, respectively, than during the handwritten phase [Odds Ratio (OR), 0.35; 95% Confidence Interval (CI), 0.32 - 0.38] and [OR, 0.25; 95% CI, 0.23 - 0.28]. Potential error sources associated with handwritten prescriptions, such as illegible prescriptions, non-standard abbreviations and incomplete prescriptions, were entirely eliminated with CPOE adoption. Significant differences in error types were observed between handwritten and electronic prescriptions (p<0.001). However, errors related to incorrect dosage, frequency and unit of measurement increased under the CPOE system compared to handwritten prescriptions (p<0.001). A significant reduction in odds occurred with wrong unit of measurement [OR, 0.61; 95% CI, 0.52 - 0.72) followed by frequency errors [OR, 0.58; 95% CI, 0.47 - 0.73) from the 3 months to 6 months post-CPOE implementation. Non-significant reductions or increments in odds were observed for other error types including wrong dosage, wrong route, wrong form, wrong strength and wrong or inappropriate drugs between the two 3-month post-CPOE periods.

Conclusion: The implementation of the CPOE system has significantly minimized the factors contributing to medication prescribing errors associated with handwritten prescriptions. However, the CPOE-related errors can still occur and may persist or change over time. To further improve prescribing safety, it is essential to address the factors contributing to these errors and periodically assess them to minimize the gap. Future studies should explore additional aspects of medication safety such as prescriber knowledge, types of medicines prescribed, long term error patterns and contextual factors including disease complexity across clinical settings, particularly with the integration of advanced clinical decision support tools.

KEYWORDS:
Computerized provider order entry (CPOE) systems, medication errors, handwritten prescription, prescribing errors, clinical decision support

INTRODUCTION

Medication errors represent a significant challenge in healthcare, posing risks of patient harm and increased costs.[1,2] These errors encompass prescribing the wrong medication, administering incorrect doses, omitting vital drugs, failing to recognize drug interactions or allergies. They can occur at various stages of the medication use process, from prescription to dispensing and administration, and may result from factors such as illegible handwriting, personal circumstances (e.g., fatigue), environmental context (e.g. interruptions or heavy workload), or lack of knowledge.[3,4]

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Corresponding Author: Lim Ming Tsuey
Email: mtlim2000@yahoo.com

To address these challenges, computerized provider order entry (CPOE) systems offer a promising solution to reduce medication errors and enhance patient safety.[5-7] CPOE systems allow healthcare providers to electronically enter and manage medication orders, replacing traditional paper-based methods. By standardizing order entry, CPOE improves legibility and reduces the likelihood of misinterpretation or transcription errors, which is a key advantage of these systems. Additionally, the integration of clinical decision support (CDS) tools into CPOE systems provides real-time alerts and reminders, preventing errors such as drug interactions, allergies, or incorrect dosages.[8-11] These tools also promote evidence-based treatments, enhancing both patient outcomes and care efficiency.[8-11]

CPOE implementation has been recognized as a benchmark for improving patient safety by organizations such as the Leapfrog Group, the Agency for Healthcare Research and Quality, and the Institute of Medicine.[12-14] Globally, CPOE systems are increasingly adopted to mitigate issues like illegible handwriting, incomplete orders, and transcription errors.[15-18] However, despite their effectiveness, CPOE systems can also introduce unintended consequences, such as wrong patient orders, duplicate orders, or incorrect order selection.[16,19,20] These unintended outcomes underscore the importance of considering both the advantages and disadvantages of CPOE implementation. Recognizing these risks is essential for developing targeted implementation strategies to maximize safety and efficiency in clinical practice.

Although CPOE systems are computer applications capable of managing orders for medications, laboratory tests, radiology, referrals, and procedures, this study focuses exclusively on their use for the electronic entry of medication orders. Among the medication errors, prescribing errors are particularly critical as they occur at the initial step of medication use process and can propagate downstream, potentially leading to adverse events. By narrowing the scope to medication prescribing errors, a significant subset of medication errors, this study provides detailed insights into how CPOE impacts prescribing rates and type. Dispensing and administration errors are excluded, ensuring a focused evaluation of prescribing errors. To systematically assess the impact of CPOE implementation, a predefined list of prescribing error types, including dose, frequency, and strength errors, was developed prior to the study. This structured approach ensures consistency in analysing error trends.

By comparing rates and types of medication prescribing errors between electronic and handwritten prescriptions across different time periods following CPOE implementation, this study aims to enhance understanding of both the risks and benefits associated with the system. Ultimately, the goal is to enhance patient safety, improve care quality and deliver greater value in clinical practice

MATERIALS AND METHODS

Study design

A before and after observational study was designed to evaluate medication prescribing errors by comparing the rate and types of errors that occurred before (handwritten) and after CPOE system implementation (electronically prescribed) over different time periods. The medication prescribing errors were extracted in two phases:

1) Phase 1 (Handwritten Prescriptions)
   During this phase, historical medication prescribing error data for handwritten prescriptions were collected from 1st January 2023 to 31st March 2023. Medication prescribing errors for this phase were extracted from handwritten prescriptions, including those intervened by pharmacy staff, with the information recorded on the prescriptions itself.

2) Phase 2 (Electronic Prescriptions)
   Two 3-month periods of electronic prescriptions with errors were extracted from the interventions conducted by pharmacy staff, with this information recorded in the Hospital Information System (HIS):

i) the first 3 months post-implementation (1st October 2023 to 31st December 2023)
ii) the second 3 months post-implementation (1st January 2024 to 31st March 2024).

Ethical approval was granted by Regency Specialist Hospital Ethics Committee. Waiver of consent was obtained as medical records were reviewed retrospectively.

Setting and population

The study took place in a 218-bed private hospital with 50,000 inpatients days annually, located in Masai, Johor, Malaysia. The hospital offers a comprehensive range of specialized healthcare services and comprises a total of 10 wards.

Prior to the implementation of the CPOE system in July 2023, all wards relied on paper medication charts for prescribers' handwritten orders. These charts underwent screening and verification by the pharmacy department before medications were dispensed to the wards. Prescribers were contacted for clarification as needed, and prescriptions were filled once errors were resolved. Intervened prescriptions were recorded directly on the prescriptions itself.

The HIS allows electronic prescribing whereby prescribers can enter prescription orders electronically into the HIS. Prescribers can select medications from pharmacy formulary or pre-selected favourite list. Subsequently, prescribers to select unit of measurement, frequency and duration. These fields are mandatory for prescription validation, as the system requires them to be filled before proceeding to the next order. All orders undergo thorough screening and verification by the pharmacy department. When an intervention is required, prescriber is contacted for confirmation and recorded in HIS. Medication preparation occurs once all details are confirmed to be correct.

The present analysis focused solely on prescriptions with errors, encompassing both handwritten and electronic prescriptions for the 6 months prior to, and 3 months and 6 months post-CPOE implementation. With this approach, we can evaluate changes in error rates and types between both types of prescriptions, as well as over time post-CPOE implementation. The data were de-identified or anonymized before analysis to protect the confidentiality of the patients and prescribers.

Table I: Characteristics of prescriptions with errors

Error Type	Pre-CPOE (Handwritten) (N=3083) n(%)	3-Month Post-CPOE (N=817) n(%)	6-Month Post-CPOE (N=606) n(%)
Legible handwriting[a]	2929(95.0)	817(100.0)	606(100.0)
Illegible handwriting[a]	154(5.0)	0(0.0)	0(0.0)
Without abbreviation[a]	2010(65.2)	817(100.0)	606(100.0)
Non-standard abbreviation[a]	1073(34.8)	0(0.0)	0(0.0)
Complete prescription[a]	855(27.7)	817(100.0)	606(100.0)
Incomplete prescription[a]	2228(72.3)	0(0.0)	0(0.0
Correct dosage[b]	3064(99.4)	606(74.2)	395(65.2)
Wrong dosage[b]	19(0.6)	211(25.8)	211(34.8)
Correct UOM[b]	3072(99.6)	443(54.2)	372(61.4)
Wrong UOM[b]	11(0.4)	374(45.8)	234(38.6)
Correct frequency[b]	3075(99.7)	595(72.8)	473(78.1)
Wrong frequency[b]	8(0.3)	222(27.2)	133(21.9)
Correct route[b]	3083(100.0)	804(98.4)	588(97.0)
Incorrect route[b]	0(0.0)	13(1.6)	18(3.0)
Correct form[b]	3059(99.2)	813(99.5)	596(98.3)
Wrong form[b]	24(0.8)	4(0.5)	10(1.7)
Correct strength[b]	3069(99.5)	814(99.6)	601(99.2)
Wrong strength[b]	14(0.5)	3(0.4)	5(0.8)
Correct drug[b]	3082(99.9)	816(99.9)	600(99.0)
Wrong/Inappropriate drug[b]	1(<0.1)	1(0.1)	6(1.0)

CPOE, computerized provider order entry; UOM, unit of measurement
[a] category A error
[b] category B error

Table II: Impact of computerized provider order entry (CPOE) on medication prescribing errors

	Handwritten	3-Month Post-CPOE	6-Month Post-CPOE	OR 95% CI	
				Handwritten and 3-Month Post-CPOE	Handwritten and 6-Month Post-CPOE
Total number of prescriptions reviewed	59663	43363	44317	-	-
Total number of prescriptions with one or more errors	3083	817	606	-	-
Total number of errors	3532	832	617		
Rate of medication prescribing error, %	5.92	1.92	1.39	0.35(0.32-0.38)*	0.25(0.23-0.28)*
Mean number of errors per prescription	1.14	1.02	1.02	-	-
Error type					
Wrong dosage[b]	19 (0.03)	211 (0.49)	211 (0.48)	15.34 (9.60 -24.54)*	15.02 (9.38-24.02)*
Wrong UOM[b]	11 (0.02)	374 (0.86)	234 (0.53)	47.18 (25.90-85.94)*	28.79 (15.72-52.70)*
Wrong frequency[b]	8 (0.01)	222 (0.51)	133 (0.30)	38.37 (18.95-77.69)*	22.45 (11.00-45.82)*
Other type errors[b]	39 (0.07)	21 (0.05)	39 (0.09)	0.74 (0.43-1.26)	1.35 (0.86-2.10)

CPOE, computerized provider order entry; CI, confidence interval; OR, odd ratios; UOM, unit of measurement
*p<0.001
[b] category B error

Table III: Impact of the computerized provider order entry (CPOE) system on medication prescribing errors with time, by error type

Error Type	3-Month Post-CPOE n (%)	6-Month Post-CPOE n (%)	p-value	OR 95% CI
Total Prescriptions	43363	44317		
Wrong dosage [b]	211 (0.49)	211 (0.48)	0.83	0.98 (0.81 to 1.18)
Wrong UOM [b]	374 (0.83)	234 (0.53)	<0.001	0.61 (0.52 to 0.72)*
Wrong frequency [b]	222 (0.51)	133 (0.30)	<0.001	0.58 (0.47 to 0.73)*
Wrong route [b]	13 (0.03)	18 (0.04)	0.41	1.35 (0.66 to 2.76)
Wrong form [b]	4 (0.01)	10 (0.02)	0.13	2.45 (0.77 to 7.80)
Wrong strength [b]	3 (<0.01)	5 (0.01)	0.53	2.45 (0.77 to 7.80)
Inappropriate drug [b]	1 (<0.01)	6 (0.01)	0.07	5.87 (0.71 to 48.77)

CPOE, computerized provider order entry; CI, confidence interval; OR, odd ratios; UOM, unit of measurement
*p<0.05
[b] category B error

Definition of terms
Medication error
A medication error refers to any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the healthcare professional, patient or consumer.[21] These errors can occur at various stages, including prescribing, dispensing, administering or monitoring medications.

Some types of medication prescribing errors[15,22] identified in this study were as follow:

- Wrong/Inappropriate Drug: Prescribing a medication different from the intended one or indication or one which patient is allergic.
- Wrong Dosage: Prescribing an incorrect amount of medication, either too much or too little.
- Wrong Strength: Prescribing a medication with a strength different from the intended dosage.
- Incorrect Route: Prescribing a medication for administration through an incorrect method (e.g., oral instead of intravenous).
- Wrong Frequency: Prescribing the medication for administration at an incorrect timing.
- Wrong Dosage Form: Prescribing the incorrect physical form of the medication (e.g., tablet instead of liquid).
- Incorrect Unit of Measure: Prescribing the medication using an incorrect unit of measurement, leading to dosage miscalculations.
- Illegible Handwriting: Difficulties in interpreting the prescription due to unclear or illegible handwriting, potentially leading to errors in dispensing or administration.
- Incomplete Prescriptions: Occurring when essential information, such as dosage, frequency, instructions or patient details, is missing from the prescription, which can result in confusion or errors during medication administration.
- Non-Standard Abbreviations: Involving the use of abbreviations that are not standardized or understood universally, leading to misinterpretation and potential errors. This includes abbreviations specific to a particular healthcare discipline or facility, which may not be recognized by all healthcare professionals.

These medication prescribing errors fall under either category A (circumstances or events that have the capacity to cause error, e.g.; illegible handwriting, incomplete information or non-standard abbreviations) or category B (an error occurred but did not reach the patient), as categorised by the National Coordinating Council for Medication Error Reporting and Prevention (NCC MERP) index, as they were detected during prescriptions screening.[21]

Study outcomes
The outcomes of interest were the rate and type of medication prescribing errors between handwritten prescriptions versus electronic prescriptions pre- and post-CPOE implementation.

Statistical analysis
Continuous variables were presented as mean and standard deviation while categorical variables were reported in frequencies and percentages. Error rates are expressed as errors per 100 prescriptions. A p-value of <0.05 was considered as statistically significant. Data were analysed using an online Confidence Interval calculator available at: https://www2.ccrb.cuhk.edu.hk/stat/confidence%20interval/CI%20for%20ratio.htm

RESULTS

Prescription error characteristics are presented in Table I. Illegible, non-standard abbreviations, and incomplete prescriptions were prevalent during the handwritten phase but were completely eliminated with the adoption of the CPOE system. While some error types were observed in both handwritten and CPOE system, there was a notable increase in errors such as incorrect dosage, frequency, and unit of measurement under the CPOE system. Inappropriate drug errors, including drugs to which patients were allergic, were identified in the CPOE system both three and six months after its implementation.

The frequency of medication prescribing errors decreased from 5.92% to 1.92% after three months and further to 1.39%, six months post-CPOE implementation (Table II). The odds of an error occurring three months and six months post CPOE implementation were 65% and 75% lower, respectively, than during the handwritten phase [Odds Ratio (OR), 0.35; 95% Confidence Interval (CI), 0.32 - 0.38] and [OR, 0.25; 95% CI, 0.23 - 0.28]. The mean number of errors per prescription was found to be higher during the handwritten phase. Significant differences in error types and rates, particularly incorrect dosage, frequency, and unit of measurement under the CPOE system compared to handwritten prescriptions (p<0.001).

Table III summarizes the impact of the CPOE system on medication prescribing errors over time, categorized by error type. A significant reduction in odds was noted for wrong unit of measurement (39%) and wrong frequency errors (42%) post-CPOE implementation ($p<0.05$). Non-significant reductions or increments in odds were observed with wrong dosage, wrong route, wrong form, wrong strength, and wrong/inappropriate drugs between the two time-frames post-CPOE.

DISCUSSION

This study is among the few to evaluate medication prescribing errors following the implementation of CPOE with integrated basic CDS tools and to track their evolution over time in an inpatient hospital setting. Georgiou et al. reported that very few published studies have evaluated the real-world impact of CPOE systems, underscoring the importance of studies like ours that assess actual clinical outcomes in a working hospital environment.[23] Our findings showed a significant reduction in medication prescribing errors when comparing handwritten prescriptions to electronic prescriptions. The transition from handwritten to electronic prescriptions resulted in the complete elimination of issues such as illegible handwriting, non-standard abbreviations and incomplete prescriptions, which were prevalent during the handwritten phase. While certain errors, such as wrong unit of measurement and wrong frequency, initially increased after the introduction of the CPOE system, their rate dropped over time. However, dosage errors remained consistent throughout the post-CPOE period.

Given these findings, it is essential to consider the role of the integrated CDS tools in driving these improvements. While this study demonstrated a significant reduction in overall medication prescribing errors following the implementation of CPOE, the extent to which the CDS component contributed to this outcome warrants further examination. CDS tools provide real-time alerts and reminders, assisting prescribers in identifying potential drug interactions, incorrect dosages, and allergy-related contraindications. These features likely played a role in reducing specific types of prescribing errors[24] by providing timely feedback to the prescribers. This feature is particularly valuable in enhancing patient satisfaction and safety by allowing providers to correct errors immediately during order entry. The ability to correct errors at the moment of prescription will thereby enhance patient satisfaction with the implementation of CPOE. If the CPOE system had been implemented without CDS functionalities, the reduction in prescribing errors particularly those requiring clinical judgment would likely have been less pronounced. The standalone CPOE systems primarily mitigate errors related to legibility and completeness but may not effectively address more complex prescribing errors without integrated decision support.

Consistent to findings from other studies[5,16,18], our study revealed that the CPOE system has reduced medication prescribing error by at least 65% when comparing handwritten prescriptions to those electronic prescriptions. This reduction was particularly evident in errors classified as category A under the NCC MERP index[21], which includes legibility issues, missing information, and non-standard abbreviations. Category A errors can compromise prescription clarity and accuracy, potentially leading to confusion during preparation, dispensing, or administration. The adoption of CPOE systems significantly reduced these errors by enforcing standardized electronic ordering criteria, eliminating the need for abbreviations as all drugs are selectable from a drop-down menu. Additionally, CPOE ensures legible typing with standard sized fonts and formats that are easily readable and not prone to misinterpretation. Furthermore, the system includes built-in safety checks to ensure that prescriptions cannot proceed without all required information, further reducing the likelihood of missing information errors commonly seen in handwritten prescriptions.

Despite the significant reduction in overall prescribing errors, our study highlighted important shifts in error patterns, particularly regarding dosage, unit of measurement, and frequency errors. Unlike category A errors, which were effectively mitigated by the system, these specific errors showed a marked increase, with their rate rising from 0–5% in handwritten prescriptions to 20–45% in the post-CPOE phase. Notably, these errors were intercepted during pharmacist screening before reaching the patient, classifying them as category B errors. This pattern differed from that of category A errors. A key contributor to this increase appears to be selection errors associated with drop-down lists, a well-documented concern in other studies.[16,19,25,26] These errors occur when prescribers mistakenly choose the wrong option from a prepopulated list, resulting in unintended medication orders or incorrect dosing regimens. Another contributing factor include auto-populated information functionality of the system. When prescribers enter the first few letters or numbers of a drug name or dosage, the system suggests prefilled options that can be mistakenly selected.[27] Importantly, both the handwritten and CPOE prescriptions in this study were issued by the same team of specialists, yet selection errors were much lower in the handwritten prescriptions. This highlights the role of system design in contributing to these errors. Another possibility for the observed differences in error patterns was the under-detection of errors during the handwritten prescription phase. Factors such as illegible handwriting, lack of standardization, and incomplete documentation of pharmacist interventions could have led to missed or unrecorded errors. Some errors may have gone unnoticed due to time constraints, oversight, or variability in pharmacist expertise. Consequently, the apparent increase in dose and frequency errors during the CPOE phase may partly reflect improved error detection rates facilitated by electronic systems, rather than an actual rise in error occurrence. The structured data entry fields, enhanced traceability, and standardization of CPOE likely enabled more consistent error identification.

While improved detection may explain some of the observed increase, it is also crucial to acknowledge that CPOE implementation has introduced new challenges that require careful evaluation. Selection errors, particularly those associated with drop-down lists[16,19,25,26] and auto-populated fields[27], have been identified as major contributors to CPOE-related prescribing errors. Additionally, factors such as

prescriber knowledge gaps, contextual circumstances, fatigue, or inherent interface design flaws within the[3,4,28,29] may contribute to these errors. Alert fatigue, where frequent system notifications desensitize prescribers, can lead to oversight or dismissal of critical alerts.[8-11] Similaly, prescriber knowledge gaps, particularly regarding system functionalities and medication dosing, further increase the risk of CPOE-related errors.[3,4,28,29] Workflow misalignment, where system prompts do not align with clinical practices, can also impact prescribing accuracy.[3,4,28,29] To ensure continuous improvement, it is essential to periodically assess these factors, refine CPOE functionalities, and implement targeted interventions, such as enhanced clinical decision support tools and structured prescriber training. Our findings underscore the dual nature of CPOE's impact where it effectively eliminates preventable handwriting-related errors, it also introduces new, technology-related challenges[16,19,20,25,26] that require targeted interventions. To maximize the benefits of CPOE and minimize unintended errors, ongoing system refinements, user training, and monitoring mechanisms are essential. Future efforts should focus on enhancing the adaptability of CPOE to evolving clinical workflows, refining decision-support features, and implementing safeguards against selection errors. By continuously optimizing CPOE functionalities and addressing emerging challenges, hospitals can ensure that such systems contribute meaningfully to medication safety and overall patient care.

Over time, our study observed a significant reduction of approximately 40% in specific selection errors following CPOE implementation. Notably, there was a further decline in certain error types when comparing the initial three months following CPOE implementation to the subsequent three months. Specifically, wrong unit of measurement and wrong frequency errors showed even greater reductions in the second three-month period, suggesting that as users became more familiar with the system, their proficiency helped mitigate selection and navigation errors. Additionally, continuous updates and enhancements to the system to address initial usability issues or user interface challenges may have contributed to this improvement, making the system more intuitive and user-friendly. Changes in types and rates of CPOE-related errors over time have also been reported in other studies.[30,31] However, it remains unclear whether the types and rate of CPOE-related errors that emerge immediately after implementation are the same as those that persist or evolve after years of system use. Further studies need to be carried out to address this gap and to better understand the long-term implications of CPOE on medication safety.

While our study found that the implementation of CPOE significantly reduced medication prescribing errors, it is important to recognize the effectiveness of CPOE on medication safety can vary depending on the clinical setting and specific system configuration, as shown in previous studies.[23,29] Factors such as workflow integration, system configuration and prescriber training are crucial in determining safety outcomes. The unintended consequences such as new types of errors due to overdependence on technology, increased physician workload and workflow issues[3,4,16,19,20,23,29] underscores the importance of considering these variables in CPOE implementation. Recognizing how these factors influence CPOE's real world impact on medication safety is essential to optimizing its effectiveness across different clinical settings.

This study possesses several strengths. Firstly, it was conducted in a real hospital setting, providing findings applicable to actual clinical practice. Secondly, it directly compared error rates before and after CPOE implementation, offering a clear assessment of its impact. Thirdly, it analysed data over time, revealing how error rates evolved over time following CPOE adoption. Lastly, it identified factors contributing to errors in CPOE system, highlighting areas for potential improvement. However, there are also limitations to consider. The generalizability of this study to other hospitals may be limited since it was conducted in a single centre. This limitation, is partially mitigated by the use of predefined list of prescribing error types which ensures consistency in the analysis of error trends. Future research should validate these findings in diverse healthcare settings. Additionally, the three-month duration for each study phase might not capture long-term trends or fully assess the sustainability of error reduction achieved through CPOE implementation. Moreover, the study's focus solely on prescribing errors restricts the evaluation's comprehensiveness, as it does not encompass other potential outcomes or aspects of medication safety. Further we were unable to account for potential confounding factors such as variations in the prescribers' levels of expertise or differences in the types of medications prescribed, disease complexity and unmeasured influences. As reported by Bourdeaux et al., these factors may have affected the observed prescription errors throughout the study period.[29] However, we recognise the limitation of retrospective data collection for handwritten prescriptions where some errors may not have been documented. A potential limitation of our study is that the results were not stratified by individual wards. Since the data were compiled collectively (compiled data from all 10 hospital wards), we were unable to compare prescribing error trends across different wards. Stratification could have provided additional insights into whether certain wards experienced greater improvements or encountered specific challenges following CPOE implementation. Future studies may consider a ward-level analysis to explore variations in prescribing errors and optimize CPOE implementation strategies based on ward-specific needs.

CONCLUSION

This study demonstrated a significant reduction in medication prescribing errors following the implementation of the CPOE system. It effectively eliminated issues related to illegible, inappropriate, and incomplete prescriptions. However, CPOE-related errors have varied over time, emphasizing the need for continuous monitoring. Integrated CPOE with CDS tools is essential for improving drug management quality and safety, reducing medication errors and enhancing patient safety. To sustain these improvements, it is crucial to identify and address the underlying factors contributing to CPOE-related errors and periodically assess them to minimize gaps. Future studies should explore additional dimensions of medication safety,

focusing on the long-term error patterns and the influence of contextual variables, including disease complexity. Such research could further refine our understanding of CPOE's impact across different clinical settings, especially with the integration of advanced CDS tools. This integration may offer new opportunities for enhancing patient safety and optimizing the medication prescribing process, ultimately leading to better health outcomes.

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CONFLICT OF INTEREST

The authors declare they have no conflicts of interest.

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