Computerized Physician Order Entry (CPOE) in Reducing Medication Error: A Narrative Review

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ABSTRACT

Medication error leads to death and injury every day, causing lower quality of life and spend almost 1% of total global health expenditure. One of the solution of to prescribing error is using technology such as Computer Physician Order Entry (CPOE). This study purpose is to assess the use of CPOE in reducing medication error. The research method is a review of the narrative literature using systematic research, with 14 included studies. CPOE systems in hospitals were found to be capable of reducing medication errors especially in prescribing and administrative stage. However, CPOE system can be associated with new types of medication error, therefore, CPOE system must considered human factor, tailored according to the need of the hospital, and continuous training to reduce medication error.

Keyword: *Computer Physicians Order Entry; Medication Error; Hospital.*

INTRODUCTION

Medication errors cause at least one death every day and injure approximately 1.3 million people annually in the United States of America alone. While low- and middle-income countries are estimated to have similar rates of medication-related adverse events to high-income countries, the impact is about twice as much in terms of the number of years of healthy life lost. Globally, the cost associated with medication errors has been estimated at US$ 42 billion annually or almost 1% of total global health expenditure (World Health Organization, 2017). Medication errors are preventable mistakes in prescribing and delivering medication to patients, such as prescribing two or more drugs whose interaction is known to produce adverse effects or prescribing a drug to which the patient is known to be allergic (World Health Organization, 2000).

The modern pharmaceutical armamentarium represents one of healthcare's great advances. The growth of medication has led to a huge increase in the complexity of the medication prescribing and administration process. It has been estimated that at least 5% of hospital patients experience an *adverse drug event* at some point during hospitalization. Drug related incidents of adverse events was 73 in 2,967 patients day, with 27 of them is life threatening (D. W. Bates, Leape, & Petrycki, 1993). The frequency of medication error incidence in prescribing is bigger (56%) than any other process such as transcribing (6%), dispensing (4%), and administration (34%) (David W. Bates, Leape, & Cullen, 1998).

Therefore, the prevention strategies to adverse drug events will need to tackle both prescribing and the monitoring phase (Gurwitz et al., 2003). Many of the solutions will be technological: the role of computerized provider order entry (CPOE) as one of the many solutions(Forrester, Hepp, Roth, Wirtz, & Devine, 2014). Computerized provider order entry (CPOE), sometimes referred to as computerized physician order entry or computerized provider order management (CPOM). According to Graban, this CPOE system is one

technological method for reducing handwriting errors, for pharmacy prescriptions, laboratory test orders, or other communications. The Leapfrog Group estimated that if CPOE were implemented at all urban hospital in the United States, almost 1 million serious medication errors could be avoided each year(Graban, 2016). The key is to simplify the process and provide less opportunity for error. It is by instituting computerized prescriber order entry (CPOE). But, implementation of CPOE itself known to be high in cost. For example, in 2009 at US, the implementation of CPOE included in the Health Information Technology for Economic and Clinical Health provision that cost USD 19 billion in total(Forrester et al., 2014).

There is limited information about the benefit of CPOE in reducing medication error in hospitals. Therefore, the aim of this narrative review of the CPOE implementation with reduction of medication error in the hospital setting.

RESEARCH METHODOLOGY

Literature Search

To identify relevant publications, we performed a systematic search by Proquest, Google scholar and EbscoHost, using the keyword 'computerized physician order entry', 'computerized provider order entry', 'medication error', and 'hospital'. We sought to narrative synthesis the results of systematic review, and primary research of the CPOE + medication error on hospital settings.

Study Selection

After title screening, we examined abstracts and selected articles that met all of the following inclusion criteria: (1) Primary research (any study design) , narrative reviews or systematic reviews categorizing, describing the impact of CPOE used on medication error; (2) intervention studies were included; (3) in a hospital setting; (4) publications in English or Bahasa Indonesia. Restriction of the search includes the availability of complete articles.

RESULTS AND DISCUSSION

Search

Our literature search yielded 17,048 citations that were screened for relevance: the title doesn't suit our objectives, duplication and doesn't suit the inclusion criteria, which left 14 articles that were included in the narrative review (Fig 1).

A descriptive and narrative synthesis of the data was undertaken to understand the implementation effect of CPOE on medication error. Restriction of the search includes the availability of complete and articles.

Classification of Studies

Five of fourteen studies were a systematic review that reported a reduce number of medication error after implementing CPOE, especially when CPOE is bundled with clinical decision support systems. One systematic review reported a reduce number of prescribing error but not compelling. One systematic review and one study (observational study) reported a medication error associated with CPOE.

Six studies were done at the hospital: two of the studies are observational studies, three studies are prospective before and after study, and one is retrospective comparison before and after study. The primary studies conducted in various inpatient settings including emergency department, community hospitals, intensive care unit, neonatal ward, and orthopedic surgery unit (shown in table 1).

Medication Error After CPOE Implementation

One study from Kazemi were conducted in the neonatal ward and report that CPOE system did not significantly change the error rate if done without the decision support (error rate 53%), but after implementing CPOE with decision support, the errors significantly reduce to 34%. Kazemi, et al found that dose errors were more often intercepted than frequency errors with over-dose as the most frequent type of medication errors. Transcription

errors did not reduce after the CPOE implementation, which could be caused by ignorance of the physicians to the alert, because the physicians could not understand the reason of the alerts(Kazemi & Ellenius, 2011). Two of the studies were done at the ICU, one from Armada et al found a decreased number of prescription error (with the error rate 44,8% with handwritten orders and 0,8% at the final electronic phase)(Armada et al., 2014), whereas Cho et al describe a high prescription and administration error rate despite long experience with a CPOE system. The administration errors and documentation errors were prescription errors and verbal order processes(Cho, Park, Choi, Hwang, & David, 2014). One of the study done by Sard et al were performed in a pediatric emergency department with an addition on a medication list (quicklist) to a computerized physician order entry system and found a significant reduction in medication prescribing errors (1,9 error per orders, compared with 18,3 per 100 orders when the list was not used) with elimination of error in wrong formulation, allergy, drug-drug interaction, and rule violations(Sard et al., 2008). One of the study which done by Leung et al were conducted in five community hospital that newly implemented CPOE, with exception for psychiatric and neonatal services with one hospital excluded the emergency, obstetrical, and surgical departments because it has not been implemented. Leung et al found an increase rates of adverse drug events (ADEs) and potential ADEs(Leung et al., 2012). One study were conducted by Hernandez et al using before-after observational study in a orthopedic surgery unit with two days for each period. Hernandez found the use of electronic prescribing led to a significant 92% decrease in prescribing errors (30.1% vs 2.4%) and 17.5% significant decrease in administration error (17.1% vs 14.2%) (Hernandez et al., 2015)). Van Rosse et al identified twelve studies that took place at the intensive care (randomized trial or observational study design), and concluded that the introduction of CPOE system reduces medication prescription errors, but did not reduce the mortality rate or reducing ADE or clinical outcome(van Rosse et al., 2009).

Reckmann et al identified 12 studies (pre-and post-implementation CPOE studies, time series, cross-sectional, cross over and comparative cohort). Reckmann divide the population of study to pediatric and adult population and found that CPOE with clinical DSS result in relative reduction with various number in prescribing error(Reckmann, Westbrook, Koh, Lo, & Day, 2009).

Wolfstadt et al include 10 studies (pre/post analysis, time series analysis, controlled cross-sectional trial) with clinical DSS but only half of the studies indicate the reduce number of ADEs(Wolfstadt et al., 2007).

A systematic review by Radley et al drawn also found a reduced number of prescription error, but it is unclear whether it would translate to the reduction of medication harm to patients(Radley et al., 2018).

Glover in his study identified 43 studies (6 RCT, 21 non RCT, 1 observational study control, 11 observational study non-control, 4 cohort and time-series studies), and 31 of these studies reported reduced medication error from the use of CPOE system(Glover, 2011).

Medication Errors Associated with CPOE

The use of CPOE as a part of health technology has also contribute to new type medication error. One study from Brown et al, using a systematic review identified 34 studies (qualitative data). Brown identified 8 key themes associated with CPOE-related prescribing errors: computer screen display, drop-down menus and auto-population, wording, default settings, nonintuitive or inflexible ordering, repeat prescription, and automated processes, user's work processes, and clinical decision support systems (Brown et al., 2017). Computer screen display affect the patient information that viewed by the physicians, drop-down menus (e.g., patient's names, medication names, drug dosages, etc.). And auto-population whereby on entering the first few letters (or numbers) of a drug name (or dose), will display information suggestions that could result in prescription error. The wording of the text used within CPOE system may have different meaning from the user's perspective. Restrictive changes in default settings of order sentences containing drug name, form, and dosage caused prescribing errors. Non-intuitive ordering or information

transmission cause medication error by the inflexible ordering for complex prescription. Interoperability issues with incompatibility between a prescribing system and a community pharmacy system cause misleading of the information and can caused medication error. Repeat prescription and automated processes make a harder detection of prescription error because the prescription do not get the error update. Users work processes means the delay of the medication order (of all the patient of the same ward) until the end of ward round cause risks for recall the medicine for each patients, and the used of the physicians' account by the nurse to work under their account. The clinical decision system that

Over-alerting or under-utilization can also result in medication error (Brown et al, 2017). These all are related to human factors and user-centered design (Brown et al., 2017). Brown et al suggest a simple solution might be to organize the screen layout to combine all medication (oral and IV) with minimal navigation required, and data labels should be clear to the user and guide them to separate areas where further specific information can be obtained. Villamanan et al using an observational study also mention the main type error of CPOE were wrong medication selection mostly caused by a mistake in selection from a drop down list and changes in drug administration route in sequential therapy (20,9%), improper data placement (11,5%), inappropriate drug allergy registration (8,8%), inappropriate use of the free-text field (15,4%), and inappropriate time of giving the scheduled treatment (9,4%)(Larrubia & Villaman, 2013). Villamanan et all suggest the continuous training, the standardization, and integration of CPOE program (Larrubia & Villaman, 2013).

CONCLUSION AND RECOMMENDATIONS

Conclusion

We affirmed the use of CPOE in reducing medication error in hospital setting, especially CPOE can reduce prescribing and administration error rates. CPOE shows no evidence in reducing clinical ADE or clinical outcome. Implementation issue in CPOE system including medication error associated with new types of prescribing error.

Recommendations

Therefore, in developing CPOE system, the human factor and user-centred design must be considered. The continued training, standardization also needed to reduce the number of error associated with CPOE system. Although CPOE cost of implementation is high, it is effective to reduce additional medication error in prescribing and administration field. Hospitals must be encourage to choose the right CPOE system which tailored to hospital need and give enough training to the user to optimize the use of CPOE.

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Table 1. Details of the Studies Evaluating the Impact of CPOE on Medication Errors

Study (Reference)	Study Type	Study Setting	Number of studies	Included study design	Outcome	Conclusion
Systematic review						
Rosse et al	CPOE compared with no CPOE	Hospital (pediatric, and ICU patients including adults)	12	Observational studies	CPOE reduce medication prescription error (RR: 0,08), potential ADEs and actual ADEs showed non significant decrease (RR 0,65), and mortality rate were not significantly influenced (RR 1,02)	CPOE reduce medication prescription error respectively, but no evidence in reducing ADEs and mortality rate.
Reckmann et al	CPOE with CDSS	Hospital (pediatric, adult, ICU)	12	Observational studies	Nine of twelve studies resulting in decrease in prescribing error rates significantly (ranging from 29 to 96%)., one of the studies reporting an increasing number of prescribing error (30-44% increase in IV prescribing errors for infusion and fluid orders), one studies reported the medication were less likely to be incorrect after CPOE. But CPOE also resulting in new types of errors such as inappropriate dosage form for a required route, selection of an inappropriate product, incorrect dose, frequency, or formulation from a dropdown menu, inappropriate use or selection of default doses and missed drug allergies.	The effectiveness of CPOE to reduce prescribing errors is not compelling and is limited by the modest study sample sizes and designs.
Wolfstadt et al	CPOE with CDS	Hospital (adult, pediatric, ICU) and ambulatory care (outpatient)	10	Pre-post study, time-series, observational	CPOE with CDS decrease ADEs significantly (P≤0,05) in 5 of the 10 studies (50%). Four studies reported a non-statistically significant reduction in ADE rates, and 1 study demonstrated no change in ADE rates.	More research was needed to evaluate the efficacy of CPOE with CDS across the various clinical settings.
Radley et al	CPOE	Hospital (ICU, emergency	9	Observational, pre-post	CPOE system decrease the	CPOE can substantially

Study (Reference)	Study Type	Study Setting	Number of studies	Included study design	Outcome	Conclusion
Systematic review						
		department, pediatric, adult)		study	likelihood of error on order by 48% (95% CI 41% to 55%)	reduce the frequency of medication errors in inpatient acute-care settings, but unclear if this translates to reducing the harm to the patients.
Charles et al	CPOE and CPOE with CDSS	Hospitals	51	Pre-post test study	CPOE implementation resulting in 12.5 to 48 percent reduction in medication errors and decreased 91 percent of prescribing error	CPOE systems in hospitals were found to be capable of reducing medical error and ADEs, especially when it is bundled with CDSS. However, CPOE systems face major barriers associated with adoption in a hospital system, mainly high implementation cost and physician's resistance to change.
Glover Jefferey	CPOE with or without CDSS	Hospital (adult ICU, pediatric, adult	43	RCT, non-RCT, observational study	CPOE has positive outcome (total 72,1%) in administration error, 23,3% negative outcome or CPOE increasing the number of medication error, and 4,7% on neutral outcome.	CPOE system implementation reduce errors in medication administration and medication errors.
Brown et al	CPOE with CDSS	Hospital, outpatient, primary care	34	Observational study (qualitative)	8 key themes associated with CPOE prescribing and auto-population, wording, default settings, non-intuitive or inflexible ordering, repeat prescriptions and automated processes, user's work processes, and clinical decision support systems.	y themes associated POE prescribing errors relate closely to human factors and user-centered design.. It should be prioritized when developing CPOE systems.
Kazemi et al	Without CPOE, CPOE with and without CDSS	1 hospital (neonatal ward)	Neonates who received antibiotics or anticonvulsants	Controlled before-after	Reduction in prescription error with the introduction CPOE system with CDSS (52% vs 50% vs 33% with $p < 0,001$), transcription error was not significantly different in the three periods(1% vs 1% vs 1%).	CPOE without the decision support functionality does not reduce non-intercepted dose and frequency medication errors of antibiotics and anticonvulsants. But when paired with a dose decision support system, it is capable of reducing there errors. The system is not effective in reducing transcription

Study (Reference)	Study Type	Study Setting	Number of studies	Included study design	Outcome	Conclusion
Systematic review						
						errors)
Armada et al	CPOE+CDSS	1 hospital (Cardiac ICU)	Adult inpatient	Prospective before-after	Reduction to prescription error, administration error ($p < 0,001$)	A significant reduction in 6 error types: drug name, pharmaceutical form, dosage, units of measure, route, and frequency administration.
Cho et al	Vendor CPOE system	1 hospital (surgical ICUs)	Medical chart review	Prospective observational	More than 50% of the prescription included at least one error. The highest prescription error category is omitted information on route (72,5%), and verbal order as the highest (63,8% vs 36,2% routine order).	High prescription and administration error rates despite using CPOE system. A significant portion of these errors were intercepted by nurses.
Sard et al	Medication list + CPOE system	1 hospital (pediatric emergency department)	Pediatric visits (emergency)	Retrospective before-after	A significant reduction in prescribing error (reduced by 16.4 error per 100 orders).	Overall reduction in medication prescribing errors of 55% after adapting pediatric emergency CPOE system and quicklist.
Leung et al	Vendor developed CPOE	5 community hospitals	Adult inpatients	Prospective before-after	A reduction in the rate of preventable ADEs (34,0%) and increase in the potential ADEs (29,5%)	Vendor CPOE system adoption associated with a reduction in more than a third in the preventable ADE rate, thus achieving comparable benefits as internally developed systems. The observed benefit was balanced against an increase in potential ADEs.
Hernandez et al	CPOE	Hospital (orthopedic surgery unit)	Adult inpatients	Controlled before-after	There were a significant reduction in procedural errors (100%), prescribing errors(92%), and administration error (17,5%). But there was no significant impact on error at dispensing stage.	CPOE decrease medication error but also associated with minor number of error related to surgery-specific patterns of prescription.
Villamanan et al	CPOE	1 hospital	Adult inpatients	Prospective observational	The rate of errors associated with CPOE use was 77,7% with the main types of error were wrong medication selection(20,9%), improper data selection main due to data entry into a wrong location (11,5%), inappropriate	CPOE minimize medication errors at the ordering stage, however they still occur. Mostly associated with CPOE technology itself.

Study (Reference)	Study Type	Study Setting	Number of studies	Included study design	Outcome	Conclusion
Systematic review						
					drug allergy registration (8,8%), inappropriate use of free-text field (15,4%) either by duplication or discrepancies between the medications selected through the structured template and free-text comment, scheduled treatment such as perioperative drug management (9,4%)	

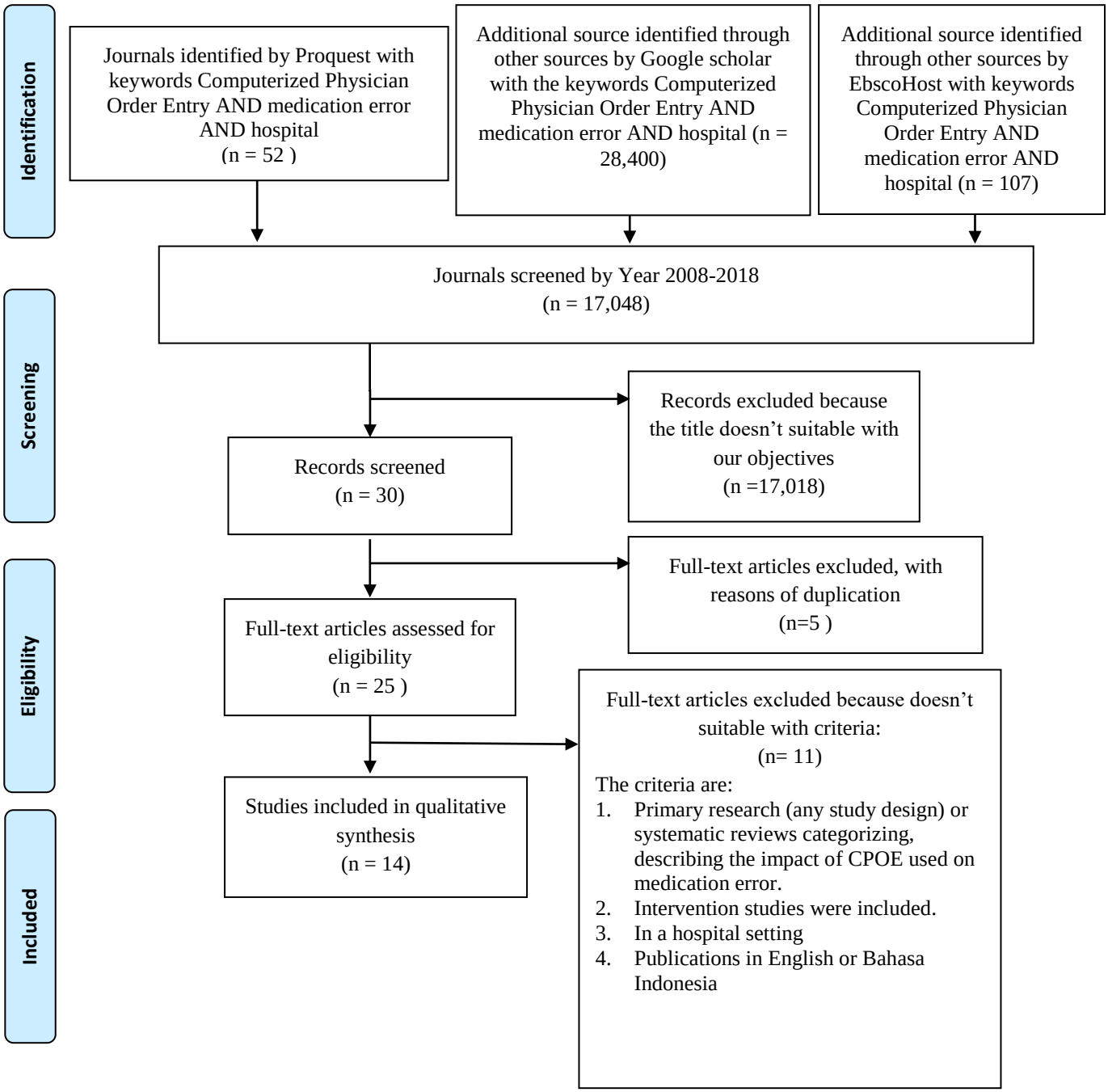

Figure 1. Flowchart of Study Selection