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The Implementation and Effects of Computerized Physician Order Entry in Healthcare Settings

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THE IMPLEMENTATION AND EFFECTS OF COMPUTERIZED PHYSICIAN ORDER ENTRY IN HEALTHCARE SETTINGS

ABSTRACT

Introduction: In the United States, medication errors has been a big problem and was the number three cause of death in 2016. Computerize Physician Order Entry (CPOE), also known as Computerized Provider Order Entry, is the process of physicians or providers entering treatment instructions or radiology, laboratory, and medication orders via computer rather than paper, and has led to a decrease in medication errors. The purpose of this study was to examine whether CPOE system could help hospitals to reduce medical errors and costs, as well as examine the new problems resulted by the use of CPOE in the United States hospitals.

Methodology: The methodology for this study utilized a literature review and a semi-structured interview. It consisted of academic sources, four electronic databases, academic journals, and government websites. Thirty-eight sources were referenced for this literature review.

Results: The literature review analyzed the benefits and drawbacks of CPOE implementation in the healthcare setting. It was found that CPOE implementation has created many benefits for the healthcare setting such as a decrease in medication errors, a higher return on investment, and a faster turnaround time. However, there has still been issues with CPOE such as medication errors and increased workload.

Discussion/Conclusion: The implementation of CPOE can reduce hospitals' medical errors and adverse drug events, as well as help hospitals to reduce expense and outweighs the potential

limitations of CPOE. The study reviewed limitations of the study that included research and publication bias, search strategy, and only four databases were used for research. Practical implications included the continual implementation of CPOE in healthcare settings.

Key Words: benefits, CPOE, implementation, limitations, medication errors, United States

INTRODUCTION

Patients safety has become the focus of the medical area around the world. However, the problems of mistaking in drugs had been increasingly resulting in morbidity and mortality, as well as increasing health care cost (Christensen, & Lundh, 2016; Kleiner, Marier, Park, & Wing, 2016). In the U.S., medical errors were the third death leading reason in 2016 (Makary, & Daniel, 2016). In pediatrics, 5%-27% of medical errors appeared when transmitting and delivering physician orders (Miller, Robinson, Lubomiski, Rinke, & Pronovost, 2007). However, most of the drug therapy problems leading to medical events such as misreading and miswriting were actually preventable (Makary, & Daniel, 2016). Therefore, implementation of modern information systems in hospitals has played an important role to reducing these medical errors (Sitting & Singh 2015).

Computerized Provider Order Entry (CPOE), belonging to the Electronic Medical Record (EHR) (Lin, Lin, & Roan, 2012; Ganju, Atasoy, & Pavlou, 2015), has been an application for physicians to write prescriptions without handwriting (Griffon, et al., 2017). This application can bring convenience for physicians, and in turn improved efficiency with five major functions: discussing patients' care plan, entering and placing patients' orders, transmitting physicians'

orders, administrating patients' orders, and reviewing order details. (Wetterneck et al., 2011; Allenet, et al., 2011).

CPOE has been a system which has allowed medical clinicians and staff to place and manage patient care orders online (Ash, Stavri, & Kuperman, 2003). CPOE systems have been closed-loop systems, which has allowed the physicians to automatically transmit their medical orders to other departments, such as pharmacy departments, avoiding transcription errors (Agrawal, 2009). In pediatric hospitals, CPOE systems can help to reduce medical errors by 7% after implementation (Walsh, et al., 2008). For medical users, CPOE has reduced medical errors, and improved the quality of drug management, as well as offering convenience for physicians by reviewing and administrating patients' orders online (Coustasse, et al., 2015). For these advantages, many governments in the United States have forced hospitals to adopt CPOE or encouraged hospitals to use this system by economic incentives (Thompson, 2010). Meanwhile, CPOE has helped to improve antibiotic ordering patterns, and reduce days when patients need to stay at hospitals (Spalding, Mayer, Ginde, Lowenstein, & Yaron, 2011). Moreover, CPOE can help to reduce both hospitals' and patients' expenditure (Khajouei, & Jaspers, 2010).

However, CPOE systems also have brought negative effects, which would have influence on efficiency and safety (Koppel, et al., 2005; Bedoch, et al., 2009). In fact, CPOE could have even increased medical errors such as disconnection, faulty computer interface, and lack of physician knowledge about the new system (Beuscart-Zephir, et al., 2005). Therefore, physicians were key individuals for implementing and developing a CPOE systems (Bedouch, et al., 2008). However, most physicians have experienced a "shakedown phase" period in the first stage of using CPOE (Sykes, Venkatesh, & Rai, 2011). The shakedown phase has been referred to the period before the advantages of CPOE appeared. Specifically, physicians could not realize the

benefits from CPOE in the shakedown phase since they still needed to overcome the limitations of using a new system (Cresswell, Mozaffar, Lee, & Willians, 2017). In this period, medical errors could have increased since there were many problems including the use of new systems, perceived resources such as stress and disuse of the new system, delayed care, slow loading, reducing patient interaction, and new types of errors (Baysari, et al., 2018). Usually, it would usually take six weeks for physicians to overcome these difficulties (Baysari, et al., 2018).

In addition, the number of duplicate orders may increase with the inappropriate use of CPOE (Wetterneck, et al., 2011). Also, CPOE increased the need of time and reduced the chances of interaction between patients and physicians face-to-face (Khajouei, & Jaspers, 2010). Meanwhile, after using CPOE, physicians have needed to take time to insert or manage orders, which wasted human resources and may limit the development CPOE (Holden, 2010). CPOE can benefit hospitals and bring negative effects to medical results. The purpose of this study was to examine whether CPOE system could help hospitals to reduce preventable medical errors due to misreading and save costs, as well as examine the new problems resulted by the use of CPOE in the U.S. hospitals.

METHODOLOGY

The primary hypothesis of this paper was that the implementation of CPOE can reduce hospitals medical errors, as well as help hospitals to reduce expense. The secondary hypothesis of this paper was the implementation of CPOE may also result in new problems such as the new types of medical errors and the difficulties for employees to enter and order specific medications.

This study used the research framework by Yao, Chu, and Li (2010). The framework (See in Figure 1) showed the process of implementation CPOE, followed by the utilization and the application of CPOE; while benefits and limitations were evaluated by its results which

provided feedback to the situation of using CPOE and the cycle continued with multiple iterations (Figure 1). This research framework was appropriate to this study and has showed success and internal validity in prior studies related to the use of health information technology (Coustasse, Tomblin, & Slack, 2013; Deslich, & Coustasse, 2014).

The methodology of this study was a literature review including three steps: (1) searching literature by key words, (2) establishing criteria for evaluating and analyzing literatures, (3) categorizing literature. Also, a semi-structured interview was performed by phone after receiving the approval of IRB and tap-recorded. Carlos Rueda who was a cardiologist at Marshall Health accepted this interview. Questions prepared for the interviews were added at the end of this study (See Appendix A).

Step 1: Literature Searching by key words

Electronic Databases from Marshall Library, Academic Search Premier, and Google Scholar were included while doing peer literature review. In addition, websites such as Health Information Technology, HealthIT.gov were also included while searching articles. Boolean operators [OR & AND] were used while searching related literature. The key words used for searching articles were “CPOE” OR “computerized physician order entry” AND “implementation” OR “implication” AND “benefits” OR “limitations”.

Step 2: literature evaluation and analysis

This literature review used Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flow diagram and followed a systematic approach. The search identified 96 articles and references were excluded (N= 35) since they were not related to the use of CPOE in the United States hospitals. References were added into this paper (N= 61) if they related to the medical errors, adverse events, and the cost of hospitals. Among these citations, 13 were

excluded since they did not relate to CPOE. Totally. Forty-four articles were included in this literature review, of them were in the results section (N= 20) (Figure 2).

Step 3: Literature Categorization

After choosing and analyzing articles, useful articles were selected and categorized into two sections based on those literature findings: Benefits of CPOE and Limitations and negative effects of implementing CPOE.

RESULTS

Benefits of CPOE Implementation

After comparing CPOE orders to handwritten orders, 8 out of 10 studies (80%) discovered that CPOE reduced prescribing errors, 43% discovered that CPOE reduced dosing errors, and 37.5% conveyed a reduction in adverse drug events (Shamliyan, Duval, & Kane, 2007). A systematic review of 25 selected CPOE studies addressed the number of deaths due to medication errors. Twenty-three of the studies reported a 14% decrease in the risk of medication errors after the implementation of CPOE (Alanazi, 2017). It has been estimated that in 2008, 17.4 million medication errors were avoided due to the implementation of CPOE (Radley et al, 2013). A study at Brigham and Women's Hospital found that serious medication errors had fallen by 88% due to CPOE implementation (White, 2015). Medication errors have occurred more often in children than adults with a 10% prescribing error rate in children (Sethuraman, Kannikeswaran, Murray, Zidan & Chamberlain, 2015). When researching CPOE effects in a pediatric unit, it was found that CPOE reduced outpatient prescription errors by 29% (Sethuraman et al, 2015).

During a two-year period from 2007 to 2009, there were 99,628 emergency hospitalizations of adults over the age of 65 due to adverse drug events (Budnitz, Lovegrove,

Shehab & Richards, 2011). In 2004 and 2005, 701,547 patients were treated for adverse drug events and 3,487 of these cases were hospitalized (Budnitz et al, 2011). It was found that from 28% to 95% of adverse drug events could have been prevented by utilizing CPOE (Adams et al, 2008).

While CPOE has been somewhat costly to implement, with the average one-time cost in 2008 of \$2.1 million due to changes in workflow and installing new systems, it has saved money over time (Adams et al, 2008). CPOE has saved healthcare facilities funds in a couple different ways. Since CPOE has been computer based, it has reduced the need for costly paper based-prescriptions and scanning prescriptions into the computer (Wears, 2016). The Everett Clinic, who has 400 prescribers and more than 300,000 patients found that CPOE cost the clinic \$18 million less from 2009 to 2014 than paper prescriptions would have over five years (Forrester, Hepp, Roth, Wirtz & Devine, 2014). A group practice consisting of only five providers found that CPOE costed \$265,000 less than paper prescribing would have from 2009 to 2014 (Forester et al, 2014). Helen Thompson, VP and CIO of NCH Healthcare system found that CPOE contributed to a 40% decrease in documents that needed to be scanned in her facility post-CPOE implementation, which she claimed saved money because the facility was paying someone to do that scanning before the CPOE implementation, but did not mention how much money was actually saved in her facility (Murphy, 2013).

It has also been proven that CPOE implementation has had a high return on investment. After examining 33 reports on CPOE return on investment in 2013, it was found that 31 reported a high return on investment, with only two of the studies showing negative results (Bresnick, 2013). Brigham and Women's hospital invested \$11.8 million in CPOE implementation over a span of 11 years from 1995 to 2006. During this time, Brigham and Women's Hospital saved

\$28.5 million, which profited the hospital \$2.2 million annually (Kaushal et al, 2006). When examining hospitals in Massachusetts, it was found that the financial benefits of CPOE system surpassed the costs of CPOE systems shortly after year two of implementation (Adams et al, 2008). After examining six Massachusetts hospitals, it was found that their average CPOE implementation costs were \$2,080,000 with an additional \$435,000 yearly CPOE costs. The average cumulative costs after five years were \$4,255,000 but the average cumulative financial benefit was \$10,545,000 (see figure 3) (Adams et al, 2008).

Some other benefits have consisted of reducing the time it takes to deliver care, reducing the time it takes for order confirmation and turnaround (up to 83%), providing clinicians with the resources to improve clinical decisions, and improving communication among clinicians and patients (Steele & Debrow, 2008). When comparing turn-around-times pre-CPOE implementation and post-CPOE implementation, there was a 79-minute decrease for laboratory orders (55.6%), a 1,146-minute decrease in radiology orders (61.6%) and a 36.7-minute decrease in pharmacy orders (83.4%) (Steele & Debrow, 2008).

According to the expert in CPOE, the systematic approach of CPOE has prevented errors in medication because there has been only a certain amount of dose options per medication. CPOE has been regulated and has made ordering medications easier. After using CPOE for eight years, the expert has found CPOE systems to be very easy to learn how to use, and that the average training time for CPOE systems has been one to two days.

Negative Effects of CPOE

While CPOE has reduced many medication errors, it has not been effective in completely reducing medication errors. A 2006 study found that CPOE has prevented medication errors from reaching or affecting the patient more than non-CPOE facilities, 34% inpatient and 36.9%

outpatient in CPOE facilities and 54.5% inpatient and 48.9% outpatient in non-CPOE facilities, but that the number medication errors that occurred in both CPOE and non-CPOE facilities were not vastly different (Zhan, Hicks, Blanchette, Keyes & Cousins, 2006).

Some medication errors have also been attributed to the use of CPOE. When examining 1.04 million reported medication errors, 63,040 were attribute to CPOE (Schiff et al, 2015). A study computed 375 erroneous orders to see if they would go through and at what ease. It was found that 201 of errors were easily placed with no warnings (Schiff et al, 2015).

In 2015, 13 different unique CPOE systems were studied and it was discovered that many of the systems failed to detect potentially dangerous medical errors (Slight et al, 2015). It was also found that warnings showed up on some systems and not on others, and that the wording was very unclear to users (Slight et al, 2015). Some CPOE systems have only shown drug allergy warnings after the medication was already ordered and left the responsibility of catching the drug allergy to the pharmacist (Koppel et al, 2005).

CPOE has brought about problems with workflow and staff members have had difficulties with entering and ordering specific medications. Of 94 hospital staff members interviewed, 24% reported that they had incurred difficulties in ordering or specifying medications daily with CPOE (Koppel et al, 2005). The most common reported error was the wrong dose of a drug and was due to prescriber misuse of the system including failure to change default CPOE settings (Korb-Savoldelli, Boussadi, Durieux & Sabatier, 2018). CPOE created several workflow problems after implementation. The first was that there has been a lack of knowledge and understanding from nurses and physicians about how IT corresponds with workflow (Aarts et al, 2007). The second was that there has been concern about the changing of workflow. The third was that there have been issues with the notification process and nurses

have not always been alerted when a new prescription has been entered into the computer. This fact has affected the workflow because nurses did not know when new prescriptions were ordered or available for patients (Aarts et al, 2007).

DISCUSSION

This study examined the benefits and limitations of CPOE. The hypothesized of this paper suggested that the implementation of CPOE can reduce hospitals' medical errors and adverse drug events, as well as help hospitals to reduce expense. The implementation of CPOE may also result in new problems such as the new types of medical errors and the difficulties for employees to enter and order specific medications.

The findings of this study can be concluded into two aspects. The benefits of utilizing CPOE for the U.S. hospitals has been saving money and increasing quality of care. However, there has been still a risk of new kinds of medical errors and the adverse drug events due to the use of CPOE. Meanwhile, the workloads may increase for medical employees to using CPOE system.

The semi-structured interview with the expert in CPOE supported research data findings. This expert suggested that CPOE has been very essential in decreasing the amount of drug errors. With only a certain amount of dosage options per medication, the expert has seen the systematic approach of CPOE significantly decrease potential dosing errors. The expert also suggested that CPOE systems have not been complicated to learn.

The drawback identified by the expert was that sometimes a higher dose has been required than what the CPOE system allows. The expert in CPOE provided the example that sometimes 200mg has been needed of a medication but CPOE only allowed 80mg to be prescribed. Because of this, the CPOE expert has been working on adjusting the CPOE system that has been used so that he can prescribe higher doses of needed medications.

Limitations

This literature review was limited since the limitation of the research strategy used in this paper. The date of articles, the numbers of articles searched, and the language of articles used limited the resources of this paper. In addition, the number of data base used by this article was also limited since the research time. It was also limited in that there was a possibility of researcher or publication bias. Meanwhile, most of the resources used by this paper focused more on the benefits of CPOE; less of them focus on the negative effects that CPOE may potentially lead to, such as the leak of patients' privacy.

In addition, there was a semi-structured interview in this paper. However, due to the time limitation, only one person was interviewed in this paper. Therefore, the working experience of the interviewer and the hospital where the interviewer work may also lead to the bias of this paper.

Practical Implication

With the frequently implementation of using Information Technology methods in daily life, there has been an obvious tendency to combine the new information technology to healthcare needs. CPOE system has been a new software, which has enabled physicians and other medical employees to access and edit medicals orders without handwriting, which finally has helped hospitals to reduce medical errors, adverse drug events, and costs.

However, with the widely use of CPOE system, new medical errors mentioned in this article (the lack of warnings of potential allergic drugs, difficulties for medical employees to edit) need to be solved. Meanwhile, some potential problems not mentioned in this paper such as the leak of privacy may also need to be focused. Finally, the rate of using CPOE in rural area may also need to focus, since operating a new system would be an extra expense to some rural

hospitals. The practical implications of CPOE implementation in hospitals will need to be more heavily researched as CPOE systems continue to be implemented and are continuously changing.

CONCLUSION

In conclusion, CPOE can help hospitals in saving money, reducing adverse drug events, and increasing quality of care. However, there was still a risk of new kinds of medical errors and the adverse drug events due to the use of CPOE. Meanwhile, the workloads may increase for medical employees to using CPOE system.

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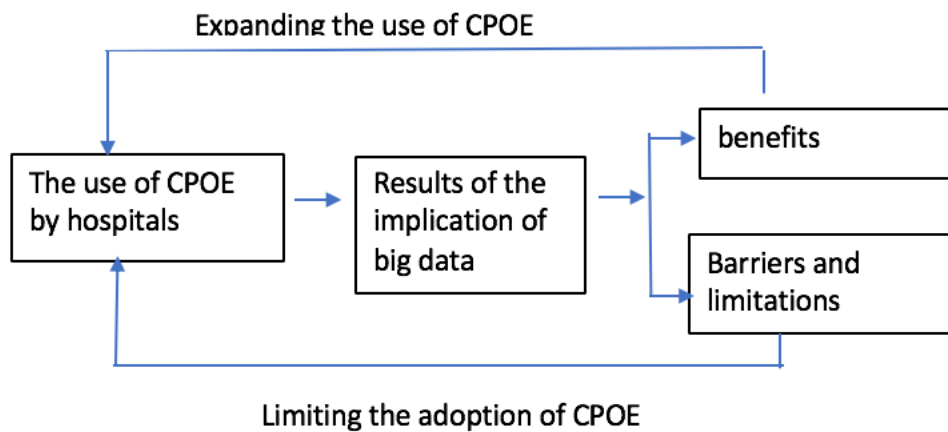


Figure 1. Research Framework Source: Adopted from Yao, Chu, & Li (2010).

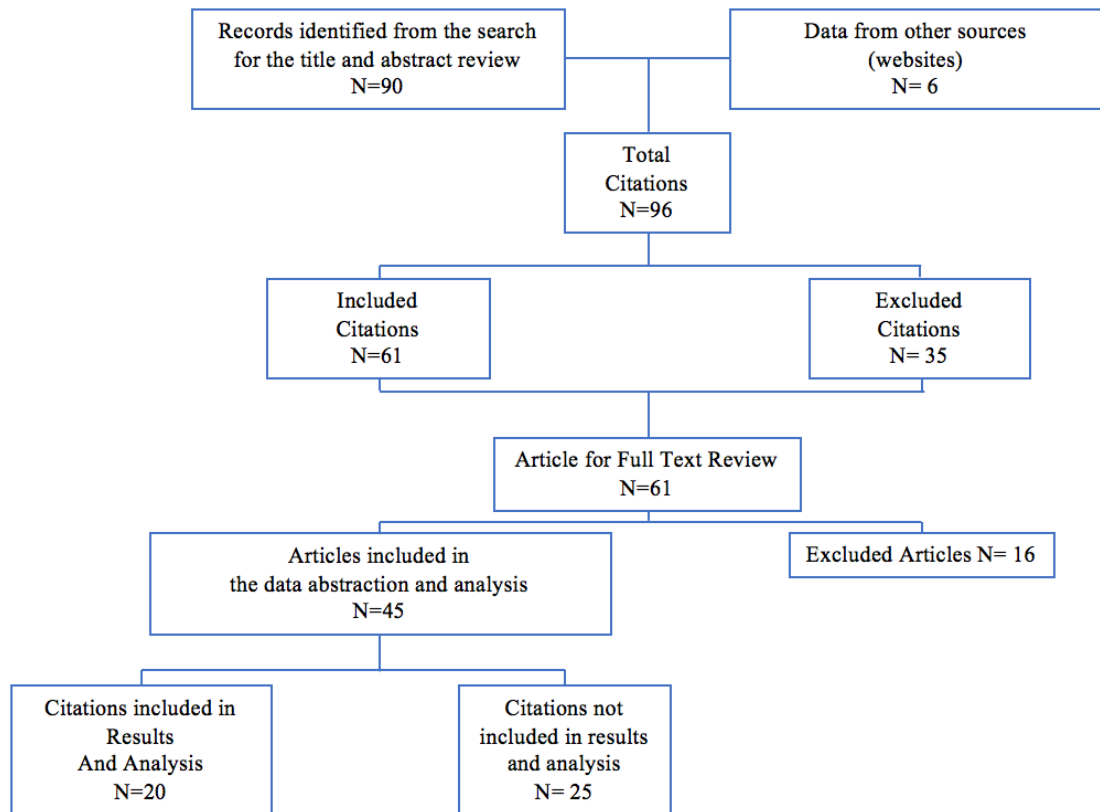


Figure 2. PRISMA

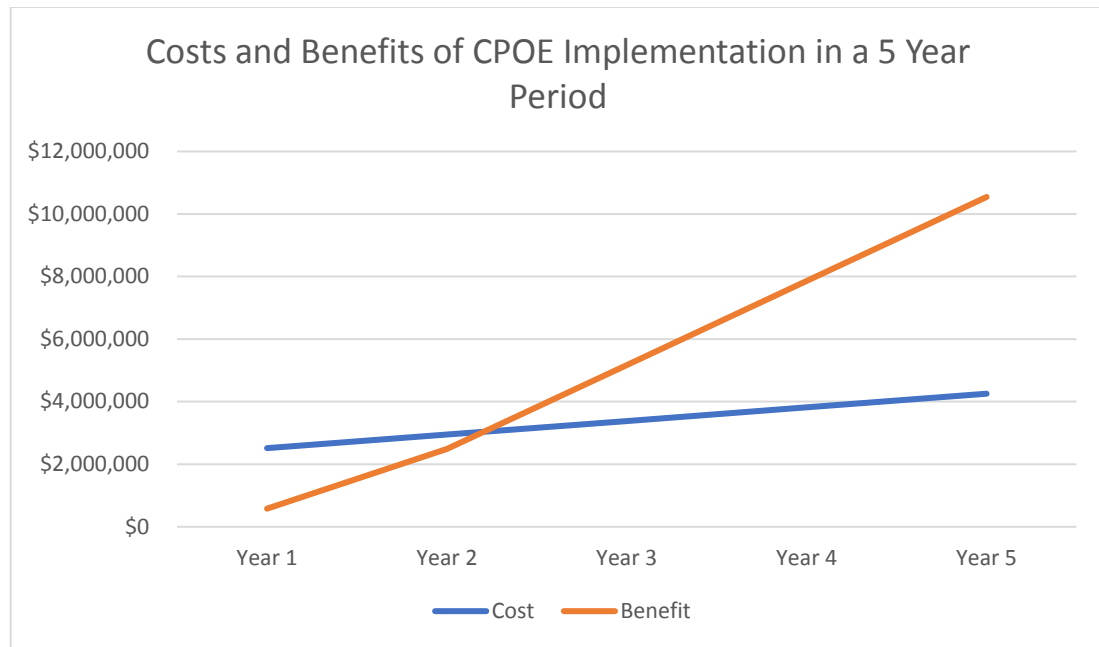


Figure 3. Adams et al. (2008).

Questions Asked in Semi-Structured Interview with an Expert in CPOE on April 4th, 2019.

1. How many years have you or your hospital used CPOE?
2. Do you think CPOE benefited you or your hospital? Why?
3. Do you think there is any limitations to use it? Why?
4. Do you think it can really help to reduce errors?
5. Who is qualified to access the system in your hospital?
6. How long did it take for you to learn to use it?
7. Have you managed to engage physicians in CPOE?
8. Do you think CPOE has affected the relationship between you and your patients? Why?