# Evaluation of computerized provider order entry systems' adoption for reducing medication errors in outpatient settings: A systematic review

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# Evaluation of computerized provider order entry systems' adoption for reducing medication errors in outpatient settings: A systematic review

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# Abstract

## Evaluation of computerized provider order entry systems' adoption for reducing medication errors in outpatient settings: A systematic review

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**Background**

This study evaluates electronic health information systems for the patient safety, in particular, computerized physician order entry systems (CPOE) for the reduction of medication error, which eventually causes avoidable patient harm. The topic of patient safety has been widely spoken all over the world in recent years as patient harm often leaves people with disabilities or even causes death. Thus, this paper will conduct a systematic review on one part of electronic health information systems, which includes e-prescribing systems and clinical decision support systems and their impact on medication error rates in adults.

**Methods**

The systematic review was performed by two individual reviewers based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) using PRISMA 2020 guidelines. The PubMed (2002-2022), Scopus (2001-2022), Cochrane Library (2000-2022), Web of Science (2000-2022) and The Lancet (1981-2022) were searched by the reviewers for the literature review. Systematic search yielded 214 articles. The initial screening of titles and abstracts performed by two reviewers individually has resulted in 35 articles to be included in full-text review.

**Results**

A total of eight studies met inclusion criteria and measured the effect of CPOE and electronic prescribing systems on medication errors in outpatient clinics. The studies included are pre-post studies (n=5), randomized control trials (n=1), other observational interventional studies (n=2). One study was conducted in Middle East, one in Taiwan, one in Canada and five other studies included were conducted in the United States of America. Two of the 3 studies on effectiveness of electronic prescribing compared to traditional prescribing in reducing medication errors demonstrated a significant decrease in medication error rates 20% and 55% reduction rates after implementation of CPOE in the chosen settings. One study conducted in two different settings at different time periods showed 25% and 2%

reduction rate. On the effectiveness of electronic prescribing with CDSS compared to electronic prescribing without CDSS, 28.5% reduction rate in overall inappropriate prescription rate in short-term and insignificant reduction rate in long-term was shown. The research identified significant rate of acceptance of alerts and recommendations by physicians in two studies (51.1% and 67%) and lower in other two studies (9.2% for DDI alerts, 23.0% for drug-allergy alerts; 3.06% for short term, 2.31% for long-term). There was no significant difference between acceptance rates of on-demand and computer-triggered CDSS.

**Conclusion**

First, the review provides clear information on the importance of CPOE implementation when paper-based system is in use, which can significantly reduce the medication error rate in the outpatient settings. Secondly, the review identified that integration of CDSS to electronic prescribing can positively impact number of medication errors in patients with renal insufficiency. Lastly, the review suggests high acceptance rate of various types of alerts by physicians for improving completeness of prescriptions, not only for medication but for laboratory test prescriptions as well.

# 1 Introduction

## 1.1 Background

This study evaluates electronic health information systems for the patient safety, in particular, computerized physician order entry systems (CPOE) for the reduction of medication error, which eventually causes avoidable patient harm and sometimes resulting in patients' death. Thus, the literature review focusing on field of patient safety and digital health interventions, including the issues and systematic literature analysis has been conducted for the development of the scope of research.

The topic of patient safety has been widely spoken all over the world in recent years as patient harm often leaves people with disabilities or even causes death. WHO suggests "On average, an estimated one in 10 patients is subject to an adverse event while receiving hospital care in high-income countries", which constitutes a large percentile of trauma causes. 134 million adverse events due to unsafe care occur in hospitals in low- and middle-income countries, contributing to around 2.6 million deaths every year (WHO, 2021). Insecure medication procedures and errors, including inappropriate injections and dosages, unclear prescriptions and abbreviation use, are a primary cause of avoidable harm that alone cost estimated amount of 42 billion USD of losses a year worldwide. (WHO, 2017)

A recently published Global Patient Safety Action Plan for 2021–2030 suggests the seven strategic objectives towards eliminating avoidable harm in health care, among those building high-reliability health systems and organizations that protect patients daily from harm is one of the key points established.

The systematic review on reduction in medication errors in hospitals due to adoption of computerized provider order entry systems has been analyzed in 2012 by Radley et al. and the following was concluded. Despite CPOE systems' effectiveness at preventing medication errors, adoption and use in US hospitals remain modest. Current policies to increase CPOE adoption and use will likely prevent millions of additional medication errors each year. Further research is needed to better characterize links to patient harm (Radley et al., 2013).

In addition, a recent systematic review of literature on the impact of electronic health records on health care quality highlights the evidence that electronic health records systems tend to improve health care quality and reduce medication errors. However, the sufficiency in the number of quality of researches on this topic was low at the time of research performance (Campanella et al., 2015).

Thus, this paper will conduct a systematic review on one part of electronic health information systems, which includes e-prescribing systems and clinical decision support systems and their impact on medication error rates in adults.

### 1.2 Purpose

This systematic review aims to provide an overview on the effects of digital health interventions – computerized physician order entry systems (CPOE) in particular, for reducing medication and prescription error.

## 2 Literature Review

There are three core terms this systematic review will put emphasis on, which are computerized provider order entry, clinical decision support systems and medication error.

### Computerized Provider Order Entry

Computerized provider order entry (CPOE) refers to the process of providers entering and sending treatment instructions – including medication, laboratory, and radiology orders – via a computer application rather than paper, fax, or telephone. CPOE technology often includes built-in clinical decision support tools that can automatically check for drug interactions, medication allergies, and other potential problems. CPOE is an electronic prescribing system and can otherwise be called as e-prescribing or computerized physician order entry system.

### Clinical Decision Support Systems

A Clinical Decision Support System (CDSS) is one part of the health management information system created to assist health professionals (both doctors and nurses) in making clinical decisions related to the patient's condition. CDSS, which has always been related to the use of EHR (Electronic Health Record), is a key element in efforts to improve the quality of health services and patient safety. CDSS is one of the solutions to minimizing the risk of errors in treatment and improving the accuracy of diagnostic examinations, thus impacting the better quality of life of patients (Manuel Vélez-Díaz-Pallarés et al., 2018).

### Medication error

Medication error is an error occurring in the treatment of the process of the patient that is potentially harmful to the patient the treatment is under the supervision of a health worker who can be prevented. The high rate of medication errors in hospitals is a significant patient safety issue. Medication errors have consistently been attributed to longer hospital stays, increased costs, significant morbidity, and even death. In intensive care units (ICUs) the prevalence of errors and adverse patient outcomes is higher and of greater severity than in general wards (Cullen et al., 1997). There are plenty of studies that have been conducted since the transition from paper-based ordering to commercial CPOE systems in ICUs found all the studies that have been made, the most significant result that has been identified is there is actually an overall reduction in medication prescribing error rates following CPOE, and the medication errors found is varied (Prgomet et al., 2017).

### Literature Review of Systematic Reviews

This section of the current paper is a report on pre-review research. To identify research scope and research question for current systematic review on CPOE systems' effectiveness, a review of existing literature was conducted in further paragraphs. Radley et al. (2013) in their systematic literature review researched the effect of CPOE on medication error and concluded the significant decrease of medication errors in inpatient acute-care hospitals, however further research of effects on patient harm is suggested. Another systematic review and meta-analysis on effect of CPOE and CDSS on medication errors, lengths of stay and mortality in ICUs by Prgomet et al. (2017) showed 85% decrease in medication error rates and 12% decrease in mortality rates in ICUs. Moreover, most of the included studies were of moderate quality and none rated as high quality.

In addition, Velez-Diaz-Pallares et al. (2018) aimed at evaluation of the impact of CPOE with CDSS on medication error and adverse drug event rates in their systematic review and identified CPOE reduces overall medication error rate. However, it was reported the CPOE implementation can lead to new errors.

Dalton et al. (2018) on their review on computerized prescription to reduce inappropriate prescribing in hospitalized elderly patients concluded there is significant reduction in potentially inappropriate medications. On the contrary, the review suggests insufficient evidence that computerized interventions can reduce patient-related outcomes such as hospital length of stay, readmission rates or mortality rates on a day-to-day basis. The authors suggest there is a need for larger scale RCTs to identify the true impact on cost and patient-related outcomes, and research on the factors affecting the implementation of computer-generated medication recommendations should be further conducted.

Reckmann et al. (2009) in their systematic review focused on finding evidence to prove CPOE systems reduce prescribing error rates among hospital inpatients and the following has been identified. The evidence-base reporting the effectiveness of CPOE to reduce prescribing error is not compelling and is limited by modest study sample sizes and designs. It is recommended by the reviewers that new studies should involve larger sample sizes, multiple sites, control trials and unified error and severity reporting.

The scoping review by Weir et al. (2012) on the analysis of quality of systematic reviews CPOE impact on clinical outcomes shows the quality of included reviews is moderate and only one study conducted a full qualitative synthesis and total heterogeneity was very high in the 3 studies reporting it.

The current literature review shows previous systematic reviews included studies of moderate quality at most, low number of large-scale control trials aimed at identification of effect of CPOE on patient-related outcomes, the results of all systematic reviews are based on non-compelling evidence. Multiple limitations were common in most of the reviewed systematic reviews, such as small sample size, low number of RCTs in the included studies and majority of the studies were limited to one site. No published systematic review in our pre-review research results was conducted solely focusing on outpatient clinics. Most of the published systematic review did not include CDSS influence on medication error or adverse drug events.

# 3 Research Objectives and Methods

## 3.1 Research objectives

The main objective of this systematic review was to identify whether:

(1) implementation of CPOE systems in outpatient settings affects the medication error rate;

(2) integration of CDSS to CPOE impacts the medication error rate in outpatient clinics; and

(3) to analyze effectiveness of alert systems in physician's medication error rate.

### 3.2 Search strategy and selection criteria

The systematic review was performed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) using PRISMA 2020 guidelines.

The PubMed (2002-2022), Scopus (2001-2022), Cochrane Library (2000-2022), Web of Science (2000-2022) and The Lancet (1981-2022) were searched for the literature review. PubMed possesses more than 34 million citations for biomedical publications from Medline. Scopus is a reliable abstract and citation database providing reliable data in variety of areas. The Cochrane Library is a collection of databases with wide variety of independent evidence to aid health policy management. The Web of Science provides citation index databases academic journals and other documents in academic field. The Lancet is a weekly peer-reviewed journal.

The databases were searched using the key questions raised as follows according to PICO strategy: Population (P) for “patients”; Intervention/Comparison (I/C) for “computerized provider order entry”; Outcome (O) and “medication error”. Synonyms for search engines were also used during literature search as indicated in Table 1. Search strategy was limited to “outpatient clinics” settings as well.

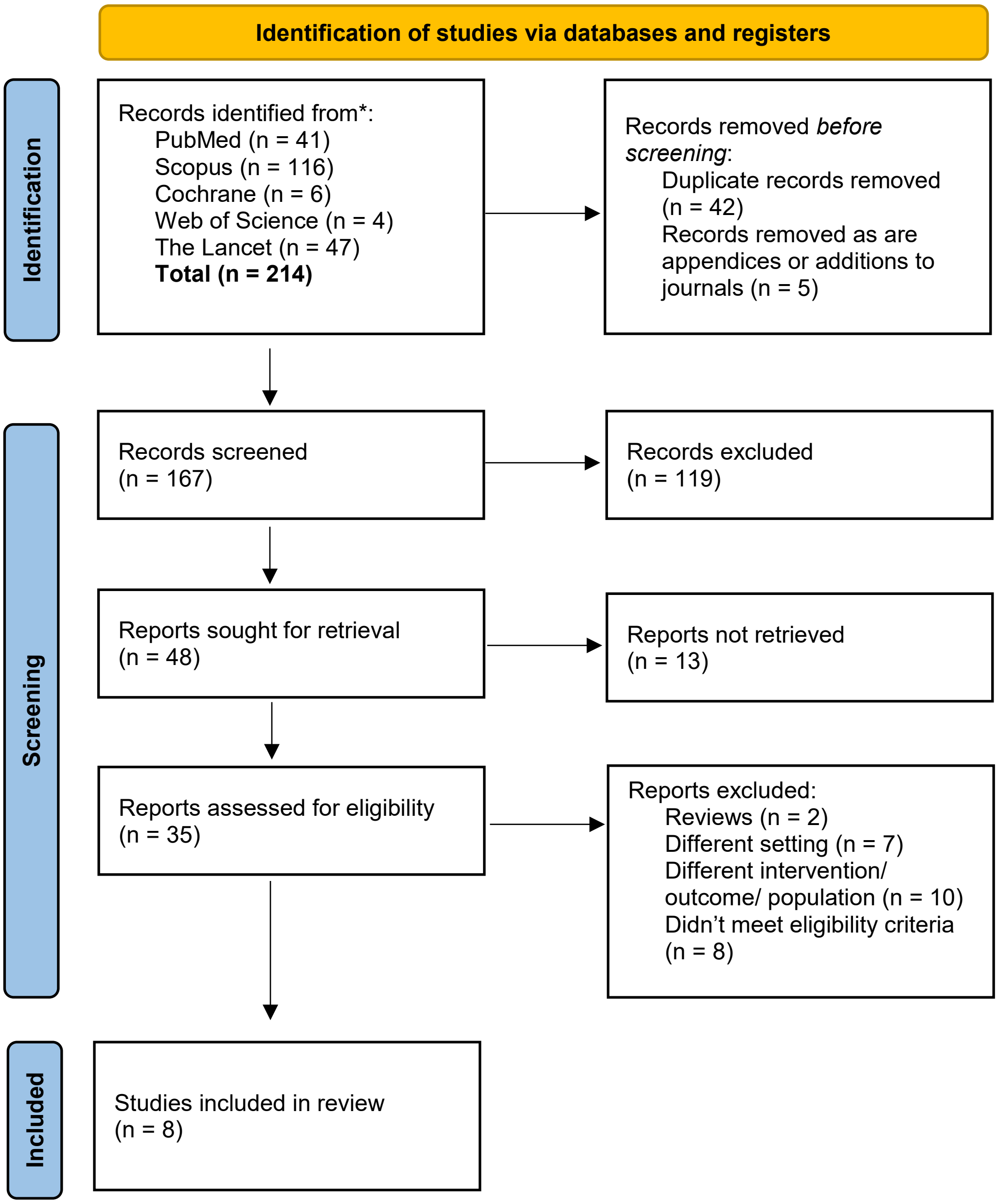
Systematic search yielded 214 articles. The initial screening of titles and abstracts performed by two reviewers individually has resulted in 35 articles to be included in full-text review. Review articles, papers indicating different settings, commission reports, opinions, notes and comments were excluded during title and abstract screening, as well as full-text screening.

Articles in which full text was unavailable or was not found (n = 13) were excluded from the review as well. Studies not written in English nor based on humans were also excluded.

### 3.3 Eligibility Criteria

Full-text review was conducted by two independent reviewers and was corresponding with the following eligibility criteria: (1) interventional studies, including control trials, pre-post intervention study; cross-sectional observational studies, prospective and retrospective studies; (2) studies conducted in outpatient settings; (3) studies including clinical decision support systems and/or alert systems along with CPOE and/or alert acceptance rate. Studies that did not fulfil research objectives completely are excluded from this review. All disputes and disagreements were resolved by discussion and mutual agreement between two systematic reviewers.

**Table 1. PRISMA 2020 flow diagram for systematic review**



# 4 Results

A total of eight studies met inclusion criteria and measured the effect of CPOE and electronic prescribing systems on medication errors in outpatient clinics. The studies included are pre-post studies (n=5), randomized control trials (n=1), other observational interventional studies (n=2). One study was conducted in Middle East, one in Taiwan, one in Canada and five other studies included were conducted in the United States of America (Table 2).

**Table 2. Table of studies included in the systematic review**

| No. | Study details | Study design | Subject of the study/ classification |
|---|---|---|---|
| 1 | Ababneh et. al. (2020) | Cross-sectional observational pre-post study | E-prescribing efficiency in comparison with Traditional prescribing |
| 2 | Devine et al. (2010) | Quasi-experimental, pretest-post-test study | E-prescribing efficiency in comparison with Traditional prescribing |
| 3 | Overhage et al. (2016) | Pre-post study of ADE rates | E-prescribing efficiency in comparison with Traditional prescribing |

| | | | |
|---|---|---|---|
| 4 | Li et al. (2022) | Pre-post study of inappropriate prescription rates | CDSS alerts efficiency in comparison with no CDSS |
| 5 | Steele et al. (2005) | Pre-post study of CDSS alerts | CDSS Generated Alert Acceptance Rate |
| 6 | Isaac et al. (2009) | Retrospective observational study | CDSS Generated Alert Acceptance Rate |
| 7 | Shah et al. (2006) | Intervention study of CDSS alerts | CDSS Generated Alert Acceptance Rate |
| 8 | Tamblyn et al. (2008) | Cluster randomized controlled trial | CDSS Generated Alert Acceptance Rate |

**Effect of Electronic Prescribing on Medication Error Rates in Outpatient Settings Compared to Traditional Prescribing**

Three studies directly analyzed the impact of electronic prescribing systems on medication error rates in outpatient clinics (Table 1). One of the CPOE systems analyzed did not have any CDSS integrated to the system, other two included different extent of CDSS.

Ababneh et al. (2020) in their cross-sectional study analyzed the medication error rates in electronic prescription and paper prescription systems in two different hospitals in Jordan, taking the approach of clinical pharmacist identifying medication errors. They reported 288 (11.5%) and 231 (9.2%) prescription errors for paper prescription and electronic prescription systems, respectively, which resulted in 20% decrease in prescription errors.

Devine et al. (2010) in their quasi-experimental, pre-post-test study in the United States compared error rates before and after implementation of CPOE system in the hospital and identified the frequency of errors decreased from 18.2 to 8.2% after CPOE implementation with a reduction rate of 55%. In addition, further inspection of results shows a significant reduction rate of 67% and 40% in drug-disease interaction errors and drug-drug interaction errors, respectively.

In another pre-post implementation study in two ambulatory care facilities in Boston and Indianapolis, Overhage et al. (2016) analyzed the impact of CPOE in reducing preventable medication errors and adverse drug events, using data on paper-based prescriptions and electronic prescription. Study showed the electronic prescription systems were associated with 25% and 2% reduction rate in total preventable adverse drug events in Indianapolis and in Boston correspondingly.

**Table 3. Table of studies evaluating the impact of CPOE on medication error rates in outpatient clinics.**

| Study details | Study design | Study population and setting | Clinical Decision Support |
|---|---|---|---|
| Ababneh et. al. (2020) | Cross-sectional observational pre-post study<br>3 months | Prescriptions paper-based system (n=2500 handwritten) and electronic system (n=2500 electronically prescribed).<br>*Outpatient setting* | Limited CDS |
| Devine et al. (2010) | Quasi-experimental, pretest-post-test study<br>12 months | Prescriptions written before (n=5016 handwritten) to after (n=5153 electronically prescribed).<br>*Ambulatory setting* | Limited CDS |
| Overhage et al. (2016) | Pre-post study of ADE rates<br>6 months | Adult patients in Boston, Massachusetts (n = 41,819), and Indianapolis, Indiana (n = 9128).<br>*Ambulatory setting* | No CDS |

**Table 3. (continued)**

| Method of Error Detection | Prescribing Error Rate Pre-intervention | Prescribing Error Rate Post-intervention | Reduction rate |
|---|---|---|---|
| Prescription and dispensing procedure screening by two trained clinical pharmacists | 288 errors from 2500 orders (11.5%) | 231 errors from 2500 orders (9.2%) | 20% reduction rate |
| Prescription, EHR and pharmacy prescription screening by two trained clinical pharmacists. Error association based on clinical data for 6 months after | 1012 errors from 5016 orders (20.8%) | 440 errors from 5153 orders (8.5%) | 55% reduction rate |
| Category 1: based on structured results such as coded laboratory tests<br>Category 2: based on symptoms mentioned in a provider's notes | In Indianapolis: 12.2 error rate per 10000 patient-months<br>In Boston: 5.5 error rate per 10000 patient-months | In Indianapolis: 9.1 error rate per 10000 patient-months<br>In Boston: 5.4 error rate per 10000 patient-months | In Indianapolis: 25% reduction rate<br>In Boston 2% reduction rate |

### The Effectiveness of CDSS implementation in reducing medication error (CPOE without and CPOE with CDSS alert system for pre and post, respectively)

Li et al. aimed at evaluation of the short-term (1-year pre- and 1-year post-implementation period) and long-term (1-year pre- and 3-years post-implementation period) impacts of CPOE with CDSS on inappropriate prescribing of anti-diabetic medication in outpatients with renal insufficiency in Taiwan. In their pre-post study, the analysis reported 28.5% reduction rate in overall inappropriate prescription rate in short-term (27.06 and 19.35% of inappropriate prescriptions) and reduction rate in long-term was limited compared to short-term (19.35 and 18.02%, respectively).

### CDSS Generated Alert Acceptance Rate

Another study by Steele et al. (2005) on the impact of drug-laboratory interaction alerts on medication prescribing that can cause hyperkalemia and hypokalemia nephrotoxicity, thrombocytopenia, hepatic inflammation analyzed the medication orders for which alert system ran in the background and medication orders for which alerts were displayed in pre- and post-implementation period, respectively. In their nonrandomized pre-post comparison study, the percentage of time the provider ordered the rule-associated laboratory test showed an increase when alert system was displayed on the screen (38.5 and 51.1% pre- and post-intervention, respectively, $p < 0.001$). However, there was no significant change when the alert ran on background after the implementation of intervention (17.0% and 16.2%, $p = 0.38$).

Isaac et al. (2009) in retrospective observational study analyzed the acceptance rates of drug-drug interaction alerts and allergy alerts in Massachusetts, New Jersey, and Pennsylvania, reported alert acceptance rates to be low and physicians accepted DDI alerts less often than allergy alerts (9.2% and 23.0%, $p < .001$).

Shah et al. (2006) in their intervention study of CDSS alerts improvements in 31 primary care settings and 2 hospitals by alert type acceptance rates differed significantly among different alert categories. They identified medication orders were cancelled in 993 (19%) and modified in 2,482 (48%) from the 5,182 interruptive drug alerts displayed, resulting in a 67% acceptance rate. The highest acceptance rate was observed in the duplicate drug class category (77%), followed by drug-disease alerts (53%). The lowest accept rate of 10% was seen among the drug-pregnancy alerts.

Li et al. (2022) estimated, among 27,189 alerts, 628 were accepted throughout study period and overall acceptance rate was 3.06% and 2.31% for short-term and long-term analyses, respectively.

### Randomized Control Trials

Only one RCT study complied with the research questions for this review. In a single-blinded, cluster randomized controlled trial conducted by Tamblyn et al. (2008) physicians and patients in outpatient setting were randomly divided in on-demand and computer-triggered groups, where physicians randomly were allocated to each CDSS, and patients were directed randomly to one of the CDSS in Canada. They identified that majority of prescribing errors were attributed to drug-disease contraindications with 36.4% and 35.6% acceptance rate, drug interactions (23.3%; 24.5%), and therapeutic duplications (16.1%; 14.4%) for on-demand and for computer-triggered groups, respectively.

## 5 Discussion

Current systematic review has shown limited quality research on the topic; studies that met inclusion criteria had relatively sufficient sample sizes, however, they notably varied across included studies, and most of the included papers were before and after (or pre- and post-intervention) study designs. Few authors used control groups and nearly all studies were non-randomized, few number of RCTs on the intervention – one study has been excluded from the review, due to early end of intervention as large number of false positive alerts occurred.

Half of the included studies collected data from 1 clinic/setting, quarter collected data from 2, quarter collected data from 2 and more outpatient clinic/settings. The studies that compare two electronic prescribing systems were not identified during full-text review that met our inclusion criteria. Two of the 8 studies demonstrated a significant decrease in medication error rates 20% and 55% reduction rates after implementation of CPOE in the chosen settings. One study conducted by Overhage et al. (2016) in two different settings at different time periods showed rather distinctive figures, 25% and 2% reduction rate.

As such notable difference occurred it is worth mentioning that researchers could not fully standardize the decision support system in both clinics - the system in Indianapolis had a different user interface and offered more decision support at the time of the study than did the Boston system. Secondly, providers in Boston preferred not to use the system for prescriptions of short-term medications (ex. antibiotics). Thus, the reduction rate in Indianapolis is much higher than in Boston.

We further reported on the effectiveness of electronic prescribing systems with CDSS alerts compared to CPOE system without CDSS. Li et al. (2022)

reported 28.5% reduction rate in overall inappropriate prescription rate in short-term and insignificant reduction rate in long-term, when compared to short-term implementation. The study shows significant reduction rate of 28.5% which mostly due to immediate impact of CPOE post-implementation in short-term.

However, we decided to analyze what the acceptance rate of clinical decision support recommendations and alerts by physicians was. Four of 8 included studies answered this research question and the acceptance rates were as follows.

**Table 4. Overall acceptance rates by authors**

| Authors | Acceptance rate |
|---|---|
| Steele et al. (2005) | 51.1% |
| Isaac et al. (2009) | DDI - 9.2%<br>and<br>Drug-allergy 23.0% |
| Shah et al. (2006) | 67% |
| Li et al. (2022) | Short-term - 3.06%<br>and<br>Long-term - 2.31% |

Table 4 represents estimated acceptance rates according to 4 given authors. The evidence shows a significant rate of acceptance of alerts and recommendation by physicians in two studies (Shah et al. (2006) and Steele et al. (2005)) and relatively lower in other two studies (Li et al. (2022) and Isaac et al. (2009))

Randomized control trial (Tamblyn et al., 2008) gives single point of view but was reported despite this fact in this review. Interestingly, there is no significant difference between acceptance rates of on-demand and computer-triggered groups, meaning physicians, in general, referring to CDSS on demand and physicians constantly getting alerts has no significant difference.

### 5.1 Limitations

The review was conducted with no additional financing as a part of master's degree thesis, therefore, the studies that are not publicly accessible nor available for Yonsei University (Republic of Korea) were not included in the study. Reviewers narrowed down the research topic to reduce limitations mentioned in other reviews with broader research area.

The studies included are written in English language and as other languages are not included in the review, some limitations to the result of our study have occurred. The review was limited to 5 databases and their search results.

Reviewers used only published studies and included studies that completely fulfilled their research objectives; therefore, limitations might include lack of details from other sources.

### 5.2 The importance of the review

Previous systematic reviews analyzing CPOE effects on patient safety mostly included studies of moderate quality, low number of controlled studies was identified, many studies were limited to their sample size and site, none of the systematic reviews researched only outpatient settings and few systematic reviews included CDSS influence as part of CPOE system.

Our review attempted to address all these issues and improve the results of previous systematic reviews by conducting up-to-date literature search and could answer how effective the CPOE systems in reducing medication error rates in outpatient clinics only, and included CDSS' impact on medication errors as a part of CPOE system. However, during the last decade the overall quality of published studies shows no change as majority of included studies are of a moderate quality and number of RCTs conducted on this topic and its quality stays in low level. The studies with insufficient sample sizes were excluded from the review and studies with larger sample sizes and multiple sites were included to overcome the limitations faced in previously published systematic reviews. However, small proportion of studies included were conducted only in one site.

Current systematic review provides an evidence-based overview that implementation of CPOE systems and CDSS leads to the reduction of medication error rates in adults and positively influences physicians' performance quality in outpatient settings.

### 5.3 Future perspectives

More number of viable research should be conducted in future to precisely understand the impact of electronic prescribing systems on reducing medication error and ensuring patient's safety especially in outpatient settings. It is suggested to increase the number of randomized control trials or cluster randomized trials to get justifiable results on the effectiveness of intervention in outpatient settings. Severity of medication errors should also be further analyzed.

## 6 Conclusion

The main objective of this systematic review was to identify whether (1) implementation of CPOE systems in outpatient settings affects the medication error rate; (2) implementation of CDSS to CPOE impacts the medication error rate in outpatient clinics; and (3) to analyze effectiveness of alert systems in physician's medication error rate. The review revealed there is an insufficient study limited to sample size and time. The included studies usually analyzed one clinic or department focusing on specific diseases and types of interventions, few papers that used control group were identified, subsequently, low number of RCTs was detected.

First, the review provides clear information on the importance of CPOE implementation when paper-based system is in use, that can significantly reduce the medication error rate in the outpatient settings. Secondly, the review identified that integration of CDSS to electronic prescribing can positively impact number of medication errors in patients with renal insufficiency. Lastly, the review suggests high acceptance rate of various types of alerts by physicians for improving completeness of prescriptions, not only for medication but for laboratory test prescriptions as well.

Clearly, the evidence on this systematic review CPOE with CDSS displaying alerts should be taken into consideration for adoption by hospitals and policymakers as well. However, there is an insufficient number of studies reporting on severity of medication errors, therefore, further research on this topic is required.

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WHO. (2017). WHO launches global effort to halve medication-related errors in 5 years. Retrieved November 1, 2022, from https://www.who.int/news/item/29-03-2017-who-launches-global-effort-to-halve-medication-related-errors-in-5-years

WHO. (2021). WHO 2021. Global patient safety action plan 2021-2030.

# 8 Appendix 1

## Review Protocol: Evaluation of computerized provider order entry systems adoption for reducing medication errors in outpatient settings

### Team Information

| | |
|---|---|
| **Project Lead** | Foziljon Mirzokhidov |
| **Research Team Members** | Tsogt Mend |
| **Date** | 2022.09.27 |
| **Institution(s)** | Yonsei University Graduate School of Public Health |

### Background

*Describe the population and condition or phenomenon of interest and contextualize it. In other words, describe what this review is about.*

The review aims at systematic analysis of effect of computerized physician order entry systems for reducing medication error in outpatient settings

### Objective

*Describe the justification for this review. In other words, describe why this review/the information it collects is important.*

Radley et al., 2013 in their systematic review has concluded further research is needed to better characterize links of CPOE to patient harm. Campanella et al., 2015 also highlighted the sufficiency in the number of quality of researches on this topic was low at the time of research performance. However, a systematic review has been conducted analyzing the effect of CPOE in reducing medication errors in inpatient settings (Reckmann et. al., 2009). However, there have been insufficient reviews conducted in outpatient settings.

## Review Question

| **Full Review Question**<br>*Provide the full review question in sentence format, and then break up the question according to the PICO framework (or other frameworks as appropriate).* | |
|---|---|
| What is the efficacy of electronic health records and computerized physician order entry systems for medication error in outpatient settings? | |
| **Population** | Outpatients |
| **Intervention** | “Computerized physician order entry systems” or “electronic prescribing” |
| **Comparison** | Traditional paper-based health records |
| **Outcome** | Medication error |

## Search Strategy

| **Databases**<br>*List the bibliographic databases to be searched.* |
|---|
| PubMed, Scopus, Cochrane Library, Web of Science, The Lancet |
| **Hand Searching**<br>*List journals or websites that will be hand searched for relevant articles.* |
| Google Scholar |
| **Experts or Stakeholders**<br>*If experts or key stakeholders are being contacted for additional grey literature or research, list them and how they will be contacted.* |
| No |
| **Reference Searches**<br>*If forward or backward citations will be performed (also known as chain or snowball searching), detail them here.* |
| Backward reference searching is conducted in relevant articles |

## Eligibility Criteria

*Operationalize your PICO (or other framework) concepts by explicitly stating what would and would not meet inclusion. Wherever possible, provide definitions, ICD codes or other identifiers to be as clear as possible.*

| **PICO** | **Inclusion Criteria** | **Exclusion Criteria** |
|---|---|---|
| Population | ● Adults and/or children receiving health-care services requiring outpatient treatment and medication | ● Studies conducted in inpatient or both – inpatient and outpatient settings<br>● Healthy patients not eligible for treatment or medication. |
| Intervention/ Comparison | ● Digital health interventions deemed to aid in ensuring patient safety - Computerized physician order entry systems (CPOE) or electronic prescribing systems (e-prescribing)<br>● Only CPOE and e-prescribing studies<br>(1) with Clinical Decision support system (CDSS) or alert systems; or<br>(2) without CDSS or alert systems | ● Studies not related to CPOE or e-prescribing or<br>● Not indicated as intervention |

| | | |
|---|---|---|
| Outcomes | • Patient harm outcomes, medication error outcomes, number of adverse drug events | • Studies that include near miss incidents |

## Data Extraction

*Provide a description of methods used to collect data from included studies (e.g. categories of data you intend to collect, how many people will conduct extraction, how disagreements will be resolved, etc).*

Full-text review was conducted by two independent reviewers and was corresponding with the following eligibility criteria: (1) interventional studies, including control trials, pre-post intervention study; cross-sectional observational studies, prospective and retrospective studies; (2) studies conducted in outpatient settings; (3) studies including clinical decision support systems and/or alert systems along with CPOE and/or alert acceptance rate. Studies that did not fulfil research objectives completely are excluded from this review. All disputes and disagreements were resolved by discussion and mutual agreement between two systematic reviewers.

## Study Quality Assessment

*If applicable, describe the tool(s) you will use to assess risk of bias.*

NA

## Data Synthesis

*Describe how you will analyze and summarize the included study results.*

NA

## Research Team Member Roles

*Describe the different tasks on the review and who will be responsible for what.*

| Task | Team Member Responsible |
|---|---|
| Development of search strategy | Foziljon Mirzokhidov |
| Conducting literature search in selected databases | Foziljon Mirzokhidov |
| Title and abstract screening | Foziljon Mirzokhidov<br>Tsogt Mend |
| Full-text review | Foziljon Mirzokhidov<br>Tsogt Mend |
| Qualitative analysis | Foziljon Mirzokhidov<br>Tsogt Mend |

## References

This Review Protocol was created by Sarah Visintini, Maritime SPOR SUPPORT Unit and adapted from the following resources:

Cochrane Public Health Group. (2011) Guide for developing a Cochrane protocol. Retrieved from: http://ph.cochrane.org/sites/ph.cochrane.org/files/uploads/Guide%20for%20PH%20protocol_Nov%202011_final%20for%20website.pdf.

Dartmouth Biomedical Libraries. (2012). Systematic Review Steps. Retrieved from http://www.dartmouth.edu/~library/biomed/services/lgr/docs/SR-Steps-Roles-revised.docx

Durham University Community. (2009). Template for a Systematic Literature Review Protocol. Retrieved from https://community.dur.ac.uk/ebse/resources/templates/SLRTemplate.pdf.

Warwick Medical School. (n.d.) Protocol Template: Systematic Review. Retrieved from http://www2.warwick.ac.uk/fac/med/staff/bridle/sr/protocol_template.doc.

World Health Organization. (2011). Review Protocol Template. Retrieved from http://www.who.int/hrh/education/Rec1_CPDforfacultyteachingstaff.pdf.

# 9 Appendix 2

## Table of evidence

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| Radley, D. C., Wasserman, M. R., Olsho, L. E., Shoemaker, S. J., Spranca, M. D., & Bradshaw, B. (2013). Reduction in medication errors in hospitals due to adoption of computerized provider order entry systems. | Provide the estimate of medication errors averted in hospitals due to use of CPOE<br><br>**Method:** Two nationally representative outcome estimates: the percentage and absolute reduction in medication errors in acute-care hospitals | Hospitals represented in the AHA survey were included if they provided general or pediatric acute medical and surgical care in 50 states in the USA.<br><br>Final sample included 4701 hospitals.<br><br>**Inclusion:** hospitals self-identified as | Extracted data from a systematic literature review and used meta-analytic random effects techniques to estimate three parameters: medication error rates when CPOE is not used, medication error rates when CPOE is used, and the percentage difference between them. | At the rate of CPOE adoption and implementation in 2008, our findings suggest that medication errors were reduced by ~12.5% (bounds 10.6–14.4%). This equates to ~17.4 million (bounds 0.09–27.1 million) fewer | Detection mode and medication error definitions varied across included studies<br><br>Difficult to observe and quantify other factors that may modify CPOE effects across hospitals<br><br>Funding: Agency for Healthcare Research and |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| | using supporting statistics **Data sources:** 2007 AHA survey, 2008 EHR survey, 2006 ASHP, systematic reviews. **Settings:** Hospitals **Period:** 2006-2008 | private-for-profit, private not-for-profit, or public. **Exclusion:** long-term care and federally owned hospitals, and hospitals outside the 50 states or the District of Columbia. | **Outcome:** point estimates with relatively wide bounds | medication errors over a 1-year period than would be expected without CPOE. | Quality (AHRQ) |

| | | | | | |
|---|---|---|---|---|---|
| Prgomet, M., Li, L., Niazkhani, Z., Georgiou, A., & Westbrook, J. I. (2017).<br><br>Impact of commercial computerized provider order entry (CPOE) and clinical decision support systems (CDSSs) on medication errors, length of stay, and mortality in intensive care units: a systematic review and meta-analysis. | To conduct a systematic review and meta-analysis of the impact of commercial computerized provider order entry (CPOE) and clinical decision support systems (CDSSs) on medication errors, length of stay (LOS), and mortality in intensive care units (ICUs).<br>**Method:** Systematic review and meta-analysis<br>**Data sources:** papers in Medline and Embase via | 586 unique citations were screened for eligibility<br>**Inclusion:** Studies were eligible for inclusion if they: (1) reported results for an ICU population; (2) evaluated the impact of moving from paper-based ordering to CPOE or evaluated the addition of a targeted CDSS to an existing CPOE system; (3) reported quantitative data on medication errors, LOS, or mortality pre- and post-CPOE or CDSS; and (4) | calculated relative risks (RRs) for medication errors, ICU mortality, and hospital mortality, and mean difference for ICU LOS. A meta-analysis for each outcome measure was performed using random effects models to pool the results | Twenty studies met our inclusion criteria. The transition from paper-based ordering to commercial CPOE systems in ICUs was associated with an 85% reduction in medication prescribing error rates and a 12% reduction in ICU mortality rates. Overall meta-analyses of LOS and hospital mortality did not demonstrate a | The majority of studies to be of moderate quality (13 of 20 studies), there were no studies rated as strong.<br><br>The evidence base we identified was more global, with half of the included studies conducted outside the US, making it more applicable to international settings. |

| | | | |
|---|---|---|---|
| Ovid, and The Cumulative Index to Nursing and Allied Health Literature (CINAHL) via EBSCOhost<br>**Settings:** ICUs<br>**Period:** 2000-2016 | used a randomized controlled trial or quasi-experimental study design.<br>**Exclusion:** if the CPOE system was not a commercial system, was implemented prior to the year 2000, or was implemented alongside other interventions making it difficult to assess the impact of CPOE or if CDSS was not integrated with the CPOE system | | significant change. |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| Dalton K., O'Brien G., O'Mahony D, Byrne S. (2018), Computerised interventions designed to reduce potentially inappropriate prescribing in hospitalised older adults: a systematic review and meta-analysis | To quantify the effect that these computerised interventions could have on reducing PIP in hospitalised older adults by conducting a parallel meta-analysis.<br>**Method:** Systematic review and meta-analysis<br>**Data sources:** PubMed, EMBASE, Medline (via Ovid), Web of Science, CINAHL, Cochrane | Studies were eligible if they described a controlled intervention in which an objective was to reduce PIP in hospitalised older adults (≥65 years) using computer-generated recommendations.<br><br>**Inclusion:** studies involving a multifaceted intervention would be included only if the effect of the computerised | **Outcomes:** The primary outcomes of interest for this review were as follows: reductions in PIP or patients with PIP. The secondary outcomes of interest were patient outcomes and acceptance rates of recommendations | there is insufficient evidence thus far to suggest that these interventions can routinely improve patient-related outcomes. It was only possible to include three studies in the meta-analysis—which demonstrated that intervention patients were less likely to be prescribed | There is insufficient evidence to suggest that computerised interventions can routinely improve patient-related outcomes. Larger scale multicentre RCTs are required to establish the true impact on cost and patient-related outcomes. Further research must identify the factors affecting the |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| | Central Register of Controlled Trials, PsycInfo and ClinicalTrials.gov<br>**Settings:** Hospitals<br>**Period:** Inception - 2017 | intervention on reducing PIP could be clearly determined.<br><br>**Exclusion:** No date or language restrictions were applied. | | a PIM (odds ratio 0.6; 95% CI 0.38, 0.93). No computerised intervention targeting potential prescribing omissions (PPOs) was identified. | implementation of computer-generated medication recommendations. |

| **Study details** | **Research parameters** | **Population and sample selection** | **Outcomes and methods of analysis** | **Results** | **Notes by review team** |
|---|---|---|---|---|---|
| Weir, C. R., Staggers, N., & Laukert, T. (2012). Reviewing the impact of computerized provider order entry on clinical outcomes: The quality of systematic reviews. | To Analyze quality of systematic reviews of empirical CPOE research.<br><br>**Method:** qualitative analysis/scoping review<br>**Data sources:** PubMed, CINAHL, Scopus, Cochrane, INSPEC, and PsychInfo databases<br>**Settings:** all mentioned<br>**Period:** 1987 - 2010 | Only systematic reviews were analyzed<br>**Inclusion:** Systematic reviews on clinical outcomes of computerized order entry systems.<br>**Exclusion:** Studies were excluded if they did not mention a systematic review in the title or text, report a formal search process, or report results of the search. | Data was analyzed based one QUOROM/ PRISMA ratings. | The search process yielded 185 initial unique references with 13 final reviews meeting the inclusion criteria. The rating of overall quality in the Oxman and Guyatt scale averaged 4.9 out of a possible 7 and the average mean of the sum of the other questions was 5.69. The | Limited by search strategies and capacity for article retrieval this study is limited by the information reported in the reviews themselves because not all the work done for a systematic review is reported<br><br>Findings: only one study conducted a full quantitative synthesis and overall heterogeneity |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| | | | | overall QUOROM/PRISMA ratings averaged 63% completion and ranging from 45% to 81%. | was very high in the 3 studies reporting it. The quality ratings of the 13 systematic reviews on CPOE were in the moderate range. |
| Vélez-Díaz-Pallarés, M., Pérez-Menéndez-Conde, C., & Bermejo- | To Evaluate the effect of computerized prescriber order entry (CPOE) with clinical decision support | Studies identifying hospitalized patients as population were included in | Publications on controlled prospective studies and before-and-after studies that assessed MEs | The reviewed evidence indicated that CPOE implementation led to an overall | CPOE reduces the overall ME rate in the prescription process, as well as specific types of errors, such |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
| --- | --- | --- | --- | --- | --- |
| Vicedo, T. (2018). Systematic review of computerized prescriber order entry and clinical decision support. | on medication error (ME) and adverse drug event (ADE) rates<br>**Method:** Systematic review<br>**Data sources:** MEDLINE, EMBASE, CINAHL, Cochrane in English and Spanish languages<br>**Settings:** Hospitals<br>**Period:** 2010 - 2016 | systematic review.<br><br>**Inclusion:** Papers with population of hospitalized patients, intervention – CPOE with CDS, control - manual prescription and outcomes – MEs and ADEs were included in the review.<br>**Exclusion:** Articles were excluded if they were observational studies or before-and-after studies with historical | and/or ADEs as main outcomes were selected for inclusion in the review. | reduction in errors at the prescription stage of the medication-use process (relative risk reduction, 0.29 [95% confidence interval, 0.10-0.85]; I2 = 99%) and reductions in most types of prescription errors, but CPOE also resulted in the emergence of other types of errors. | as wrong dose or strength, wrong drug, frequency, administration route, and drug-drug interaction errors. The implementation of CPOE can lead to new errors, such as wrong drug selection from drop-down menus. |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| | | controls, conference abstracts, narrative or opinion articles, letters to the editor, in-progress studies, or guidelines | | | |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| Reckmann M. H., Westbrook J.I., Koh Y., Lo C., Day R. O. (2009) Does Computerized Provider Order Entry Reduce Prescribing Errors for Hospital Inpatients? A Systematic Review | What evidence exists that CPOE systems reduce prescribing errors among hospital inpatients? **Method:** Systematic review **Data sources:** Ovid MEDLINE (1950–2007); CINAHL (Nursing and Allied Health) (1982–2007); EMBASE (1974–2007); Journals@Ovid, | Hospitalized patients are the study population. **Inclusion:** if the study design was a pre- and post-CPOE implementation or a comparative (handwritten and CPOE) study, and if one of the main outcome measures was prescribing error rates. **Exclusion:** studies not conducted in inpatient setting, non-prescription related studies, CPOE-related | Focused on changes in error rates and severity, and evidence of any new types of errors generated. International differences in prescribing practices were taken into consideration. | Identified 13 papers (reporting 12 studies) published between 1998 and 2007. Nine demonstrated a significant reduction in prescribing error rates for all or some drug types. Few studies examined changes in error severity, but minor errors were most often reported as | The evidence-base reporting the effectiveness of CPOE to reduce prescribing errors is not compelling and is limited by modest study sample sizes and designs. Future studies should include larger samples including multiple sites, controlled study designs, and standardized error and severity reporting. The |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| | Inspec via Ovid (1969–2007); International Pharmaceutical Abstract Series via Ovid (1970–2007); Cochrane Database of Systematic Reviews (third Quarter 2007); and the Cochrane Central Register of Controlled Trials (third Quarter 2007). **Settings:** hospital inpatient settings | outcomes other than medication errors or prescribing errors. | | decreasing. Several studies reported increases in the rate of duplicate orders and failures to discontinue drugs, often attributed to inappropriate selection from a dropdown menu or to an inability to view all active medication orders concurrently. | role of decision support in minimizing severe prescribing error rates also requires investigation. |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| Devine E.B., Hansen R.N., Wilson-Norton J.L., Lawless N. M., Fisk A.W., Blough D.K., Martin D.P., Sullivan S.D. (2010). The impact of computerized provider order entry on medication errors in a multispecialty group practice | To evaluate the effect of a basic, ambulatory CPOE system on medication errors and associated ADEs.<br><br>**Method:** quasiexperimental, pretest–post-test study<br>**Data sources:** a community-based, multispecialty health system not affiliated with an academic medical center. | Patients are study population.<br>**Inclusion:** Preimplementation and postimplementation prescriptions within 2002-2006 were evaluated. New and renewal prescriptions were evaluated.<br>**Exclusion:** excluded prescriptions transferred to/from outside pharmacies, as the transmittal process could cause errors. Prescriptions for devices and | The prescription was the unit of analysis. The primary outcome was whether or not an error occurred; secondary outcomes were error types or severity. The predictor was the presence of the CPOE system. | Frequency of errors declined from 18.2% to 8.2%—a reduction in adjusted odds of 70% (OR: 0.30; 95% CI 0.23 to 0.40). The largest reductions were seen in adjusted odds of errors of illegibility (97%), use of inappropriate abbreviations (94%) and missing information (85%). There was a 57% | A basic CPOE system in a community setting was associated with a significant reduction in medication errors of most types and severity levels. |

| Study details | Research parameters | Population and sample selection | Outcomes and methods of analysis | Results | Notes by review team |
|---|---|---|---|---|---|
| | **Settings:** multispecialty clinic-system in Everett, Washington **Period:** 2010 | laboratory monitoring supplies were also excluded. | | reduction in adjusted odds of errors that did not cause harm (potential ADEs) (OR 0.43; 95% CI 0.38 to 0.49). The reduction in the number of errors that caused harm (preventable ADEs) was not statistically significant, perhaps due to few errors in this category. | |

# 10 Appendix 3

## Results of full-text review

| Study | Foziljon Mirzokhidov | Tsogt Mend | Result |
|---|---|---|---|
| Ababneh et al. (2020) | Included | Included | **Included** |
| Abramson et al. (2012) | Excluded | Excluded | **Excluded** |
| Albarrak et al. (2014 | Excluded | Excluded | **Excluded** |
| Bruthans (2019) | Excluded | Excluded | **Excluded** |
| Cho et al. (2014) | Included | Excluded | **Excluded**<br>The paper analyzes override alerts. Research outcomes do not include alert acceptance rates, which does not comply with the inclusion criteria |
| Cho et al. (2015) | Included | Excluded | **Excluded** |
| Czock et al. (2015) | Excluded | Excluded | **Excluded** |

| | | | |
|---|---|---|---|
| Devine et al. (2010) | Included | Included | **Included** |
| Gandhi et al. (2005) | Excluded | Excluded | **Excluded** |
| Glassman et al. (2007) | Excluded | Excluded | **Excluded** |
| Greenberg et al. (2006) | Excluded | Excluded | **Excluded** |
| Hsu et al. (2015) | Excluded | Excluded | **Excluded** |
| Isaac et al. (2009) | Included | Included | **Included** |
| Jani et al. (2008) | Excluded | Excluded | **Excluded** |
| Kaushal et al. (2001) | Excluded | Excluded | **Excluded** |
| Kuo & Cheng (2017) | Excluded | Excluded | **Excluded** |
| Lehmann & Kim (2006) | Excluded | Excluded | **Excluded** |
| Li et al. (2022) | Included | Included | **Included** |
| Nanji et al. (2011) | Excluded | Excluded | **Excluded** |

| | | | |
|---|---|---|---|
| Overhage et al. (2016) | Included | Included | **Included** |
| Priya et al. (2017) | Excluded | Excluded | **Excluded** |
| Raebel et al. (2007) | Excluded | Included | **Excluded** The paper did not fulfill its objectives, as the intervention was interrupted. The trial did not continue, therefore, does not meet the inclusion criteria. |
| Schiff et al. (2017) | Excluded | Excluded | **Excluded** |
| Seidling et al. (2010) | Excluded | Excluded | **Excluded** |
| Shah et al. (2006) | Included | Included | **Included** |
| Shah et al. (2021) | Excluded | Excluded | **Excluded** |
| Shaikh et al. (2017) | Excluded | Excluded | **Excluded** |
| Steele et al. (2005) | Included | Included | **Included** |
| Tamblyn et al. (2008) | Included | Included | **Included** |

| | | | |
|---|---|---|---|
| Vanderman et al. (2017) | Excluded | Excluded | **Excluded** |
| Wong et al. (2018) | Excluded | Excluded | **Excluded** |
| Wright et al. (2018) | Excluded | Included | **Excluded** The paper analyzes drug-drug interactions alerts on adverse drug reactions and does not focus on medication errors. |
| Yeh et al. (2013) | Excluded | Included | **Excluded** The paper studies the effect of change to a commercial EHR on drug-drug interaction alerts and acceptance rates. The paper does not analyze the effect of alert systems on medication error rates, therefore does not comply with the inclusion criteria. |
| Zhou et al. (2012) | Excluded | Excluded | **Excluded** |

# 11 Appendix 4

## Search strategy

THE EVALUATION OF COMPUTERIZED ORDER ENTRY SYSTEMS ON REDUCING MEDICATION ERROR IN OUTPATIENT CARE.

**PICO**

Population – Outpatient or a day patient
Intervention – Computerized order entry systems
Comparison – non-computerized order entry systems
Outcome – medication error

Settings: outpatient clinics

----------------------------------------------------------------------------------------------------------------

**Keywords**

1. Outpatient, patient, persons, people, client
2. Computerized Provider Order Entry, Computerized Physician Order Entry, CPOE, Computerized Physician Order Entry System, Computerized Provider Order Entry System, Medical Order Entry Systems,
3. Medication error, drug error, drug use error, prescription error, inappropriate prescribing

**MeSH terms**

1. "Patients"[Mesh] OR "Outpatients"[Mesh]
2. "Medical Order Entry Systems"[Mesh]
3. "Medication Errors"[Mesh]

Settings: outpatient clinics

**PUBMED**

| Search number | Query |
|---|---|
| 5 | #1 AND #6 AND #7 AND #12 |
| 4 | ((((outpatient clinic) OR (outpatient care)) OR (ambulatory care)) OR (ambulatory center)) OR (ambulatory clinics) |

| | |
|---|---|
| 3 | "Medication Errors"[Mesh] |
| 2 | "Medical Order Entry Systems"[Mesh] |
| | ((((patient[Title/Abstract]) OR (visitor[Title/Abstract])) OR (client[Title/Abstract])) OR (persons[Title/Abstract])) OR |
| 1 | (people[Title/Abstract]) |

**SCOPUS**

( TITLE-ABS-KEY ( outpatients ) OR TITLE-ABS-KEY ( patient ) OR TITLE-ABS-KEY ( persons ) OR TITLE-ABS-KEY ( people ) OR TITLE-ABS-KEY ( client ) ) AND ( TITLE-ABS-KEY ( "Computerized Provider Order Entry" ) OR TITLE-ABS-KEY ( "Computerized Physician Order Entry" ) OR TITLE-ABS-KEY ( "CPOE" ) OR TITLE-ABS-KEY ( "Computerized Physician Order Entry System" ) OR TITLE-ABS-KEY ( "Computerized Provider Order Entry System" ) OR TITLE-ABS-KEY ( "Medical Order Entry Systems" ) OR TITLE-ABS-KEY ( "electronic prescription system" ) ) AND ( TITLE-ABS-KEY ( "Medication error" ) OR TITLE-ABS-KEY ( "drug error" ) OR TITLE-ABS-KEY ( "drug use error" ) OR TITLE-ABS-KEY ( "prescription error" ) OR TITLE-ABS-KEY ( "inappropriate prescribing" ) ) AND ( TITLE-ABS-KEY ( outpatient AND clinic ) OR TITLE-ABS-KEY ( outpatient AND care ) OR TITLE-ABS-KEY ( ambulatory AND care ) OR TITLE-ABS-KEY ( ambulatory AND center ) OR TITLE-ABS-KEY ( ambulatory AND clinics ) )

**COCHRANE**

**ID** **Search**
**Hits**

#1 (outpatients OR patient OR persons OR people OR client):ti,ab,kw (Word variations have been searched)
#2 MeSH descriptor: [Medical Order Entry Systems] explode all trees
#3 MeSH descriptor: [Medication Errors] explode all trees
#4 ("outpatient clinic" OR "outpatient care" OR "ambulatory care" OR "ambulatory center" OR "ambulatory clinics"):ti,ab,kw
#5 #1 AND #2 AND #3 AND #4

**WEB OF SCIENCE**

1. Patient OR persons OR people OR client
2. "Computerized Provider Order Entry" OR "Computerized Physician Order Entry" OR "CPOE" OR "Computerized Physician Order Entry System" OR "Computerized Provider Order Entry System" OR "Medical Order Entry Systems"
3. "Medication error" OR "drug error" OR "drug use error" OR "prescription error" OR "inappropriate prescribing"
4. 2012-2022

**THE LANCET**

1. Patient
2. Computerized Provider Order Entry OR Computerized Physician Order Entry OR CPOE OR Computerized Physician Order Entry System OR Computerized Provider Order Entry System OR Medical Order Entry Systems OR electronic prescription system
3. Medication error OR drug error OR drug use error OR prescription error OR inappropriate prescribing
4. outpatient clinic OR outpatient care OR ambulatory care OR ambulatory center OR ambulatory clinics