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Review article

Prevalence of computerized physician order entry systems–related medication prescription errors: A systematic review

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ABSTRACT

Objective: The positive impact of computerized physician order entry (CPOE) systems on prescription safety must be considered in light of the persistence of certain types of medication-prescription errors. We performed a systematic review, based on the PRISMA statement, to analyze the prevalence of prescription errors related to the use of CPOE systems.

Materials and methods: We searched MEDLINE, EMBASE, CENTRAL, DBLP, the International Clinical Trials Registry, the ISI Web of Science, and reference lists of relevant articles from March 1982 to August 2017. We included original peer-reviewed studies which quantitatively reported medication-prescription errors related to CPOE. We analyzed the prevalence of medication-prescription errors according to an adapted version of the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) taxonomy and assessed the mechanisms responsible for each type of prescription error due to CPOE.

Results: Fourteen studies were included. The prevalence of CPOE systems-related medication errors relative to all prescription medication errors ranged from 6.1 to 77.7% (median = 26.1% [IQR:17.6–42,1]) and was less than 6.3% relative to the number of prescriptions reviewed. All studies reported "wrong dose" and "wrong drug" errors. The "wrong dose" error was the most frequently reported (from 7 to 67.4%, median = 31.5% [IQR:20.5–44.5]). We report the associated mechanism for each type of medication described (those due to CPOE or those occurring despite CPOE).

Discussion: We observed very heterogeneous results, probably due to the definition of error, the type of health information system used for the study, and the data collection method used. Each data collection method provides valuable and useful information concerning the prevalence and specific types of errors related to CPOE systems.

Conclusions: The reporting of prescription errors should be continued because the weaknesses of CPOE systems are potential sources of error. Analysis of the mechanisms behind CPOE errors can reveal areas for improvement.

1. Introduction

Computerized physician order entry (CPOE) systems, along with clinical decision support systems (CDSSs), are increasingly being adopted by hospitals around the world [1]. The ultimate goal of CPOE is to improve the safety, quality, and value of patient care [2]. CPOE systems overcome the problems of illegible handwriting and prevent transcription errors [3]. Many CPOE systems also check for drug interactions in real time and alert physicians about known patient allergies, as well as calculate dose adjustments according to the patient's weight or renal function, thereby significantly decreasing the likelihood of prescribing inappropriate or unsafe doses [4]. The potential advantages of such systems include the immediate provision of drug information, better communication between healthcare staff, links with other programs, and the reduction of treatment costs [5–7]. Previous studies have shown that CPOE increases the safety of medical care by decreasing the number of medication errors, adverse drug events (ADEs), and the length of hospitalization [7,8]. Some published systematic reviews have analyzed the efficiency of CPOE systems in decreasing medication-prescription errors [9–12]. Radley et al. [13] estimated an annual 12.5% reduction in medication errors or approximately 17.4 million medication errors averted in the USA.

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However, such positive effects on prescription safety may be compromised by the occurrence of unexpected medication prescription errors directly related to the use of CPOE. Unintended adverse consequences of CPOE include increased workload, the continual need to update and improve the system, the persistent need for paper records, negative feelings about the system, and an overdependence on technology [14]. A new term, "e-iatrogenesis", has been coined to describe the new types of errors that have emerged with the implementation of CPOE [15]. Koppel et al. [16] were the first to analyze the role of electronic prescribing systems in introducing medication errors. Other studies have since investigated the negative effects of electronic prescribing systems, including a relatively low increased risk of medication errors of 1.4%–4.3% and increased mortality [17–22]. Brown et al. [23] published a qualitative systematic review in 2017 on the types and causes of prescribing errors generated by CPOE. No systematic review has quantitatively summarized the available evidence concerning the number of such errors related to the use of CPOE.

Our primary objective was to perform a systematic review, to quantitatively analyze the published evidence concerning the prevalence of medication prescription errors generated by CPOE (or systems combining CPOE with a CDSS), focusing on the nature of these errors. Our secondary objective was to qualitatively report the mechanisms responsible for the CPOE errors for each type of prescription errors described by the authors of the included studies.

2. Methods

This systematic review is presented according to the *Preferred Reporting Items for Systematic Reviews and Meta-analyses* (PRISMA) guidelines [24]. The study protocol has been registered in the PROSPERO database (registration number: CRD42017054349).

2.1. Definitions

CPOE systems are "any system in which clinicians directly enter orders for medications, tests, or procedures into an electronic system, which then transmits the order directly to the recipient responsible for carrying out the order (*e.g.*, the pharmacy, laboratory, or radiology department)" [25]. In recent years, CPOE systems have frequently been combined with a CDSS, which provides clinicians with reminders or recommendations, to maximize the safety and quality of clinical decisions. Our systematic review focused on medication orders. Medication-related CDSSs may be "basic", checking for drug allergies, duplicate treatments, and drug–drug interactions, and providing basic dose guidance and formulary decision support. Alternatively, they may be "advanced", also providing guidance concerning dose adjustments for renal insufficiency and geriatric patients, guidance for medication-related laboratory testing, and checking for contraindications during pregnancy or for a particular drug in patients with a given disease [1].

The National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP) defines a "medication error" as follows: "A medication error is any preventable event that may cause or lead to inappropriate medication use or patient harm while the medication is in the control of the health care professional, patient, or consumer. Such events may be related to professional practice, health care products, procedures, and systems, including prescribing, order communication, product labeling, packaging, and nomenclature, compounding, dispensing, distribution, administration, education, monitoring, and use." Our systematic review focused on medication errors related to prescription systems. Sittig et al. [3] defines the Health Information Technology (HIT) error 'from the sociotechnical viewpoint of end users (…) rather than from the purely technical viewpoint of manufacturers, developers, vendors, and personnel responsible for implementation'. Thus, CPOE-related medication-prescription errors "can occur even when hardware and software are functioning as designed. For instance, errors may result when users do not use the hardware or software as intended (…). Errors may also arise when two or more parts of the HIT system (e.g. CPOE application and the pharmacy's medication-dispensing system) interact in an unpredicted manner, resulting in inaccurate, incomplete, or lost data during entry, display, transmission, or storage".

2.2. Search strategy

We conducted a systematic search of MEDLINE, EMBASE, the Cochrane Central Register of Controlled Trials (CENTRAL), the Computer Science

Bibliography (DBLP), the International Clinical Trials Registry (ICTR), the ISI Web of Science, and the online reference for open bibliographic information on computer science journals and proceedings for articles published from March 1982 to August 2017 in English and French. To identify potentially eligible studies, we searched MEDLINE, using the following MeSH terms: (((“Decision Support Systems, Clinical”[Mesh]) OR ((“Electronic Prescribing”[Mesh]) OR “Medical Order Entry Systems”[Mesh]))) AND “Medication Errors”[Mesh]. We also searched EMBASE using the following search strategy: 'medication error'/exp AND ('decision support system'/exp OR 'electronic prescribing'/exp OR 'hospital information system'/exp). In DBLP, we used the following search strings:

cpoe|computerized.physician.order.entry|computerized.provider.-order.entry|computerized.prescriber.order.entry,

cdss|clinical.decision.support|clinical.decision.support.system,

Electronic.prescribing | medical.order.entry.systems | medication.errors.

The terms used for the complete search strategy are presented in Appendix 1.

Finally, we also manually searched the papers that were mentioned in previous studies as underlying References

2.3. Inclusion criteria and assessment

We included original peer-reviewed studies that quantitatively reported prescription medication errors generated by CPOE. A study was included when its primary objective was to report the number of medication-prescription errors generated by the use of CPOE, regardless of the software used. The role of the CPOE in the generation of the medication-prescription errors needed to be clearly established by the authors.

The typology of the medication errors reported also had to have been detailed for inclusion. All types of study design, other than those based on clinical scenarios, were included. All types of physicians, regardless of their training, whether general practitioners or specialists, working in hospitals or in the community, were eligible for inclusion. The patients included were adults or children and inpatients or outpatients, regardless of the drugs prescribed.

Finally, studies were excluded if they reported only qualitative results about the medication-prescription errors generated by CPOE, if only one type of medication prescription error was quantitatively reported, if medication errors occurred in steps other than medication prescription (nursing administration, for example), if the studies concerned dedicated software (such as chemotherapy preparation software), or if the role of the CPOE in the medication prescription error was not clearly established by the authors.

Two authors (VS, AB) independently screened the titles and abstracts of all retrieved reports, and then obtained full-text copies of all papers that were either potentially relevant or for which the inclusion criteria were unclear from the title and abstract. The two investigators then applied inclusion criteria and differences of opinion were resolved by consensus between the authors of the review (VS, AB, PD and BS). We recorded the number of full-text articles assessed and excluded, specifying the reasons for exclusion.