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Impact of electronic prescribing in a hospital setting: A process-focused evaluation

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ABSTRACT

Objective: To evaluate effects of a natural CPOE implementation in a hospital setting and inform the efficacy of using CPOE rather than traditional paper medication orders.
Design: A multiple-baseline, quasi-experimental study of a naturally occurring CPOE intervention, with a non-equivalent control site.
Measurements: Compliance with medication-ordering protocols and time to first dose of antibiotics.
Results: Medication orders placed using CPOE were significantly more compliant than paper-based medication orders, and first doses of antibiotics were delivered significantly faster when ordered with CPOE than when placed using the standard paper-based system ($p < .01$).
Conclusion: Findings support the use of CPOE and justify the need for interventions to increase CPOE adoption and consistent use among physicians.

1. Background

Medication errors alone are estimated to be responsible for 7000 deaths annually in the U.S. [1]. This is higher than the number of Americans who die annually as the result of workplace injuries (i.e., 5575 in 2003 [2]). The total national cost associated with preventable adverse medical events is estimated to be between $17 and $29 billion [1], and the increased U.S. healthcare costs attributable to preventable adverse drug events (ADEs) are estimated to be around $2 billion [1].

In an era of continually increasing healthcare costs, the prevention of medication errors and associated malpractice costs is a critical public health issue.

Medication errors can result from several sources, including (a) dosage administration (i.e., the patient receives the wrong amount of medication), (b) medication administration (i.e., the patient is given the wrong medication altogether), and (c) patient administration (i.e., the patient is given medication targeted for a different patient). Although not all medication errors lead to death; research suggests between 12.2% [3] and 19% [4] of all medications administered in hospitals contain some level of error in the process from ordering to administration.

1.1. *The communication factor*

Medical researchers have noted the complexity of patient management, which "involves multiple handoffs where critical information must be communicated" [5]. Errors occur at each point of the medication-ordering process [6], and fortu-

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nately the "stop and check" behaviors at the various phases of the medication-ordering process detect and correct most of these errors before they impact patient safety.

Given the sheer quantity of medication orders processed, the very real possibility of an error influencing patient safety remains. Additionally, lack of upward communication in the hierarchical organizational structures of most hospitals is suggested as a potential barrier to some nurses questioning a physician's orders [7]. For this reason, each phase of the medication-ordering process would benefit from an intervention to reduce the probability of error. Recent research pinpoints prescribing error as the primary source of ADEs [6,8], making it critical to reduce the probability of error at the medication-ordering phase of physician prescribing.

1.2. *The computer-based approach*

CPOE refers to a variety of computer-based systems used for ordering medications, each sharing techniques for automating the medication-ordering process [9] and ensuring standardized, legible, and complete orders. It is one of the number of strategies that hospitals have employed in an attempt to reduce medication errors [6]. CPOE is of particular interest because it represents a fundamental change in the way physicians operate within the healthcare system. However, transitioning to an electronic medication-ordering system involves changing physicians' habitual prescribing behavior. Additionally, research suggests CPOE implementation has a major impact on workflow for many individuals beyond the physician [10]. Thus, interventions may be needed to motivate physicians to make this fundamental change in medication ordering. In this regard, evidence of improved patient safety with CPOE is an essential initial step. The current research was designed to provide evidence-based rationale for CPOE.

A number of studies suggest CPOE is an effective and efficient means of reducing medication errors and ADEs [11–14] and may eliminate rule violations (RVs) and medication prescribing errors (MPEs) in addition to potential ADEs [15]. Additional evidence for CPOE contributing to improvements in patient safety reported from the Queen's Medical Center in Honolulu include the following results: 75% reduction in transcription errors, 30% reduction in wrong medication or route, 75% reduction in inappropriate vancomycin (antibiotic) use, 60% decrease in time to first dose of antibiotic, 85% reduction in unsigned orders, and 40% reduction in turnaround time for STAT medications [16]. Furthermore, a systematic review of several studies evaluating the impact of CPOE/CDSS systems on patient safety concludes use of CPOE significantly reduces medication error rates [17].

Another suggested benefit of CPOE is faster delivery of medication orders [16]. Research shows that antibiotic delivery within 4 h of arrival at a hospital is associated with reduced in-hospital mortality as well as reduced mortality within 30 days of admission [18]. Additionally, quicker administration of proper antibiotics is suggested to be associated with a shorter length of stay in the hospital [19], which also implicates reduced treatment costs for the healthcare system. For these reasons, the CPOE site for the research reported here wants all antibiotics to be administered within 240 min of their order.

Given the available research literature, adopting CPOE may be a viable approach to reducing medication errors and ADEs, as well as improving the quality of healthcare. However, some research has suggested CPOE may facilitate the occurrence of certain medication errors and increase rates of ADEs [8,20], as well as foster undesirable consequences including concerns about (a) alerts, (b) security, (c) interpersonal relations, and (d) reimplementation [21]. Thus, further research on the impact of CPOE on patient safety is clearly needed. The aim of this research was to evaluate the effects of a natural CPOE implementation in a hospital setting and inform the efficacy of using CPOE rather than traditional paper medication orders.

2. Method

This study was IRB approved by both hospitals and Virginia Tech. All three institutions approved retrospective review of medication order forms and informed consent requirements were waived due to de-identification of all ordering physicians and use of group data methods.

2.1. *Participants and setting*

Participants were physicians working at one of two hospitals (CPOE vs. control) as either consulting physicians under contract or as hospitalists directly employed by the hospital. They were self-selected from overall physician populations of 194 (CPOE site) and 159 (control site).

The settings were two medical centers located in southwest Virginia, both of which are owned and operated by the same corporate entity as for-profit hospitals. The CPOE site was a 521-bed tertiary facility, and the control site was a 146-bed general acute-care facility.

The CPOE hospital administered an average of approximately 3800 doses per day, and this site set the organizational goal of achieving a 75% rate of CPOE use for all medication orders by the end of 2006. While the control hospital may not be directly comparable due to a size disparity, it was selected for inclusion due to (a) its likely implementation of CPOE in 2008, (b) its similar baseline levels of meeting medication-ordering criteria, and (c) its convenient location.

2.2. *Procedure*

Data were collected by research assistants working in teams of two or three. Data-collection sessions occurred 3–4 days weekly at each hospital, usually lasting 2–3 h each. Hospital personnel from the pharmacy and information systems departments of both hospitals trained the senior author and two research assistants to access and interpret relevant medication-ordering records. These researchers then trained 12 research assistants who helped accomplish the daily data collection at each hospital. The researchers had access to pharmacy personnel for clarification of specific information on written medication orders (e.g., alternate drug names, physician signature identification, and abbreviation meanings). Medication-ordering records to be reviewed were chosen