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The unintended consequences of computerized provider order entry: Findings from a mixed methods exploration

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ABSTRACT

Objective: To describe the foci, activities, methods, and results of a 4-year research project identifying the unintended consequences of computerized provider order entry (CPOE).
Methods: Using a mixed methods approach, we identified and categorized into nine types 380 examples of the unintended consequences of CPOE gleaned from fieldwork data and a conference of experts. We then conducted a national survey in the U.S.A. to discover how hospitals with varying levels of infusion, a measure of CPOE sophistication, recognize and deal with unintended consequences. The research team, with assistance from experts, identified strategies for managing the nine types of unintended adverse consequences and developed and disseminated tools for CPOE implementers to help in addressing these consequences.
Results: Hospitals reported that levels of infusion are quite high and that these types of unintended consequences are common. Strategies for avoiding or managing the unintended consequences are similar to best practices for CPOE success published in the literature.
Conclusion: Development of a taxonomy of types of unintended adverse consequences of CPOE using qualitative methods allowed us to craft a national survey and discover how widespread these consequences are. Using mixed methods, we were able to structure an approach for addressing the skillful management of unintended consequences as well.

1. Introduction

When our study began in October of 2003, the unintended consequences of computerized provider order entry (CPOE) were a little-discussed area. Patterson et al. had identified and described what they called "side effects" of a different, but similar, kind of system, bar code medication administration (BCMA) [1]. They used a relatively structured ethnographic approach to studying BCMA in Veterans Administration hospitals and identified side effects which they believed could lead to adverse drug events (ADEs). BCMA is supposed to prevent ADEs, but there are numerous unintended consequences they documented that could lead to mistakes. They offered suggestions about how to "eliminate these side effects before they contribute to adverse outcomes" ([1], p. 540).

Problems related to clinical decision support had likewise been described in the literature. Although decision support is often cited as a reason for implementing CPOE, there has been controversy about the appropriate number of alerts and reminders, since too many tend to overwhelm and annoy

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users [2]. One 1989 report described an experiment where, to reduce the time between alert posting and review by the clinician, a flashing light mechanism was placed on top of the computer and designed to flash to let a user know when an alert was present. The system was extremely effective in encouraging a rapid response to the alert, reducing the average acknowledgment time from 28 to 1 h, but users insisted the experiment be halted because the lights were too annoying [3]. This is a dramatic example of a negative unintended consequence of an otherwise effective system.

Medical error reduction is a prime reason for implementing CPOE, but users are also concerned that new kinds of errors are being made because of clinical systems. Many papers written about CPOE gave brief mention to this concern or cited anecdotes, but there were no published studies about mistakes that could be caused by CPOE. The Physician Order Entry Team (POET), a group of researchers based at Oregon Health & Science University in Portland, Oregon, U.S.A., was conducting a study of success factors for implementing computerized physician order entry (CPOE), defined as direct entry of orders into the computer by physicians or others with the same ordering privileges, when we began noticing unintended consequences (UCs) that might lead to errors. The clearest example is entry of an order for the wrong patient because of what we call a "juxtaposition error" when an item near the one actually desired is clicked by mistake.

Colleagues doing similar qualitative studies in Australia and The Netherlands were discovering these UCs as well, and a collaborative effort in 2002 produced a general description of kinds of adverse consequences caused by clinical information systems (CIS) [4]. This was a rather startling revelation at a time when CPOE was being touted as the "leap" that hospitals should take in the interest of patient safety [5] and little attention was being paid to problems caused by CPOE. In three separate observational studies, these research teams had continually witnessed "wrong patient" juxtaposition errors. Similar errors occur when one clicks on a test or medication listed on the screen next to the one needed. The summary paper by Ash et al. highlighted the phrase "unintended consequences of CPOE," which has become widely accepted and used [4]. This paper was influenced by several monographs that dramatically describe the unintended consequences of technology in general [6–9]. Since publication of the Ash et al. paper [4], numerous papers in both medical and the medical informatics journals have further described the unintended consequences of health information technology [10–18].

With funding from the U.S. National Library of Medicine, POET has been able to conduct an in-depth study over the past 4 years utilizing both qualitative and quantitative methods to discover more about these UCs of CPOE. Data were gathered via two expert panel conferences, fieldwork at a total of six sites (one outpatient and five primarily inpatient), and a national telephone survey of all CPOE sites in the U.S.A. The aims were to identify types of UCs and strategies for preventing, managing or overcoming them, and to provide tools to help implementers address them. The following presents a summary of the research foci, methods, and results, along with general conclusions about the overall project.

2. Methods

2.1. Sample selection

The main criterion for site selection for fieldwork was that organizations have a reputation for excellence in using clinical information systems. Excellent organizations learn from their mistakes [19,20] and therefore staff members in those organizations have analyzed the issues and are knowledgeable about strategies for overcoming obstacles. We were seeking sites with personnel who would be willing to (1) describe surprises they have experienced and managed, and (2) be observed during the order entry process. Sites represented a geographic distribution, different types (e.g., teaching and community hospitals) and ownership (e.g., public and private), varying durations of experience with CPOE, and both commercially and locally developed systems. Kaiser Permanente Northwest in Oregon, selected for excellence in outpatient CPOE, uses EpicCare (Epic Systems, Madison, WI), and is a health maintenance organization. Other sites included: Wishard Memorial Hospital, a county hospital in Indianapolis, IN using the locally developed Regenstrief system; The Brigham and Women's Hospital in Boston, MA, which uses a locally developed system; Massachusetts General Hospital, Boston, MA, which uses a newer version of the Brigham system; Faulkner Hospital, a community hospital in Boston, MA, that uses the commercial MediTech system (Westwood, MA); and Alamance Regional Hospital in Burlington, NC, which uses the Eclipsys commercial system (Boca Raton, FL). We received human subjects approval from each site and from the researchers' organizations. Within each site, informants for interviews were selected based on their knowledge of what had occurred during CPOE implementation and use and their representative roles (physician, nurse, pharmacist, implementer, champion, skeptic, etc.). We observed clinicians entering orders in all areas of the hospitals and clinics. Experts for the expert conferences were selected based on hands-on experience with CPOE implementation and included clinician implementers from a variety of hospital types and vendor organizations.

2.2. Data collection

Fig. 1 illustrates the progression of data gathering, analysis, and reporting of results that occurred between 2003 and 2007, starting with a transition period at Kaiser Permanente Northwest between the success factors study and the current UC study. We gathered data at Kaiser on an ongoing basis between the spring of 2003 and winter of 2004, developing refined semi-structured interview and observational techniques during the transition to studying UCs. During that period, we conducted 29 h of observation in four clinics, shadowing 15 clinicians, and we interviewed 12 clinicians and staff members. In the spring of 2004 we held a conference of invited experts at the Menucha Retreat Center near Portland, OR to gather stories about UCs from the experts and to gain guidance about questions to ask and what to look for in the field. We then spent three to 4 days at each of our five inpatient study sites with four to six investigators on site at any one time. We conducted 390 h of observation with 95 clinicians and did 32 interviews. Obser-