Categorizing the unintended sociotechnical consequences of computerized provider order entry

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Abstract

Objective: To describe the kinds of unintended consequences related to the implementation of computerized provider order entry (CPOE) in the outpatient setting.

Design: Ethnographic and interview data were collected by an interdisciplinary team over a 7 month period at four clinics.

Measurements: Instances of unintended consequences were categorized using an expanded Diffusion of Innovations theory framework.

Results: The framework was clarified and expanded. There are both desirable and undesirable unintended consequences, and they can be either direct or indirect, but there are also many consequences that are not clearly either desirable or undesirable or may even be both, depending on one’s perspective. The undesirable consequences include error and security concerns and issues related to alerts, workflow, ergonomics, interpersonal relations, and reimplementations.

Conclusion: Consequences of implementing and reimplementing clinical systems are complex. The expanded Diffusion of Innovations theory framework is a useful tool for analyzing such consequences.

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1. Introduction

Use of computerized provider order entry (CPOE) is not yet widespread [1], but valuable lessons can be learned from the pioneering organizations that have adopted CPOE. These lessons generally involve sociotechnical issues, defined as issues involving the interplay of organizational and technical components of a system. The more we know about sociotechnical issues, the better prepared we can be for the clinical systems implementation process. For example, there are unintended consequences resulting from CPOE implementation [2], and knowledge about these consequences can potentially help avoid them in the future.

CPOE, in the narrow sense, is defined as a process in which a provider who has ordering authority uses a computer to enter medical orders directly. The process eliminates the need for an intermediary to respond to written or verbal orders given by a provider. An expanded definition of CPOE was used in this study, to include not only this narrow definition, but to also encompass accompanying processes such as decision support, documentation, and order delivery, both to the receiving department and the patient. CPOE is receiving...
growing worldwide interest because there is some evidence that it increases medical safety by reducing medical errors [3–8].

Diffusion of Innovations (DOI) theory provided the framework for this study. Diffusion has been defined by Everett Rogers as “the process by which an innovation is communicated through certain channels over time among the members of a social system” and an innovation is defined as “an idea, practice, or objective perceived as new by an individual, a group, or an organization” [9, p. 5]. The basic theory has been tested and validated in numerous studies. A great many researchers have focused on the characteristics of innovations. DOI theory outlines five attributes which have been shown in many studies to be important in assessing the diffusion potential of an innovation: relative advantage (is it better than the idea it supersedes?); compatibility (is it consistent with existing values and needs of users?); complexity (is it hard to understand and use?); trialability (can you experiment with it?); and observability (are results visible to others?). Another factor that is important in diffusion is communication, the process of sharing ideas, which can be done through a variety of channels ranging from mass communications to face-to-face interactions. Time is the third element of the diffusion process, and at the individual level people can be categorized as innovators, early adopters, early majority adopters, late majority adopters, or laggards. At the diffusion process level, time is a measure of the rate of adoption or spread of use through a population. The fourth main element of diffusion is the social system, a set of individuals or organizations through which the innovation diffuses [8].

The basic DOI theory elements of innovation attributes, communication, time, and the social system have been studied and validated in over 5000 publications since the first edition of Rogers’ book was published [9, p. xviii]. Diffusion researchers have added to our knowledge of the basic theory and extended and enriched it over the years. Information technology diffusion research was of special interest to Rogers toward the end of his career. In the last edition of the book, the late author stressed that information technology “may be changing the diffusion process in certain fundamental ways such as removing, or at least greatly diminishing, the role of spatial distance in who talks to whom about a new idea” [9, p. xvi].

Fig. 1 depicts the authors’ interpretation of the DOI model, with the addition of “consequences.” Once an innovation has been adopted, there are inevitable consequences, but, according to Rogers, the consequences of adoption are the least studied aspect of the innovation diffusion process. DOI theory outlines a classification of consequences: desirable or undesirable; direct or indirect; anticipated or unanticipated. The term “unintended” connotes consequences that are primarily both unanticipated and undesirable. Rogers has described types of consequences in words, but not graphically.

Studies in the information technology literature are beginning to focus on post-adoption behaviors such as continuance [10]. Researchers have also recognized that complex systems, even if successfully adopted by some definitions, may not be effectively used and that “unanticipated (and sometimes contradictory) changes may result from an implementation that was technologically labeled as successful” [11, p. 1].

The aim of this study is to describe kinds of unintended consequences related to CPOE in the outpatient setting. Many diffusion studies have been quantitative because they measure the numbers of adopters over time, but Rogers, stating that “the usual survey research methods may be inappropriate for investigating consequences,” [9, p. 470] has recommended qualitative methods for investigating this aspect of diffusion theory. We have selected several qualitative methods because they can be particularly useful for identifying both overt and subtle consequences, and many that users of a system do not know occur. By watching clinicians in the field, ethnographers can discover issues previously unrecognized by the subjects. We used observation and interview techniques for gathering data over a 7-month period of study at four large outpatient clinics. We developed a categorization scheme for consequences based on Rogers’ Diffusion of Innovations model and then we analyzed examples from our research using this scheme.

2. Methods

2.1. Prior data collection

Prior research at four sites formed a backdrop for the study described here. All of the organizations studied are using CPOE successfully, but they vary according to type and geographic location. Interviews at each site were held with administrators, information technology related staff, and clinical end user staff at all levels. Ethnographic observation was done in a wide variety of settings within the clinics and hospitals, including physician offices, exam rooms, pharmacies, emergency departments, intensive care units, and medical and surgical units. Analysis was done iteratively using a grounded theory approach: as each set of field notes or interview transcripts was completed, individual researchers coded them and then met to agree on final coding, patterns, and themes. Data from each new site were blended with prior results in an ongoing analysis cycle [12]. Results of these analyses have been reported elsewhere [13]. One theme that emerged during the analysis of data from the fourth site was that there exists a wide variety of unintended consequences related to implementing CPOE.
2.2. Clinics Northwest data collection

The organization under study here, which will be referred to as Clinics Northwest, uses outpatient CPOE exclusively. Data were collected at four large outpatient clinics under the same management using the same vendor-supplied electronic health record. All clinics have used the system since at least 1997. At these outpatient clinics, as at previous sites, a multidisciplinary team of qualitative researchers used observation and interview techniques to gather data. Observation was done in physician offices, exam rooms, pharmacies, and clerical staff areas. The chief focus of the Clinics Northwest data collection effort was identifying success factors for implementing CPOE. A semi-structured template for field notes was used by the five researchers doing observation and it included themes developed from prior work, including the theme of unintended consequences. The interview guide for the semi-structured oral history interviews included questions designed to elicit comments about consequences. At Clinics Northwest, investigators were able to extend the observation period over 7 months: the first observations were done in April of 2003 and the last interview in October of that year. Researchers shadowed clinicians in four clinics for a total of 29 h and did 15 h of interviewing. They shadowed 13 different clinicians and interviewed 12 individuals. The study received human subjects approval for this component of the study from both Oregon Health & Science University and the organization referred to as Clinics Northwest.

2.3. Data analysis

Field notes were transcribed from handwritten notes by the investigators themselves. Transcripts of interviews were produced from audiotapes by experienced oral history transcriptionists. When put into a format suitable for analysis, the total number of single spaced pages was approximately 350. As indicated earlier, a grounded theory approach was used to identify emergent themes. Grounded means that the words of the informant are used as a starting point for developing categories and themes [12]. Rather than starting with a predetermined priori list of code words, the informants’ own words guide code development. Applying the grounded approach as described by Miles and Huberman [14, pp. 131–132], which builds on Rogers’ Diffusion of Innovations model, the model will be referred to as the Thematic Hierarchical Network Model for CPOE Consequences. Investors mapped instances seen or heard about in the field to categories in the model, identified patterns within each theme, and further analyzed these groups.

3. Results

Prior to a detailed analysis, the team used the DOI framework for consequences to develop a graphical depiction of a hierarchical model, and then used this model during analysis to help build an understanding of CPOE consequences.

3.1. The Thematic Hierarchical Network Model for CPOE Consequences

Please see Fig. 2. According to Diffusion of Innovations theory, those who decide to implement an innovation such as CPOE do so with an intent, with a definite reason in mind. With CPOE, the intent may be workflow efficiency, cost containment, or error reduction, for example. Consequences are changes to an individual or social system as a result of adopting the innovation. They are different from intents—they result from acting on the intent. As noted earlier, according to Rogers, there are three classifications of consequences: desirable versus undesirable, direct versus indirect, and anticipated versus unanticipated [3]. During the data analysis process, the researchers further defined types of consequences in an effort to better understand them. Desirable consequences are actually the goals of processes you wish to improve. Indirect consequences are outcomes that are generally less measurable and often they are at least one step removed from the direct consequences. Unanticipated consequences, if they are actually desirable, come as happy surprises, so we use the term serendipity for them. Unanticipated undesirable consequences are the kind that most of us mean when we discuss unintended consequences, so we give them that term. Please refer to the diagram in Fig. 2 for examples. This discussion will follow the diagram from left to right.

Decision makers introduce innovations such as CPOE because they anticipate certain desirable and direct consequences. An example would be elimination of illegible orders. They also anticipate some indirect consequences such as fewer medication errors (partly resulting from elimination of illegible orders). Tradeoffs include direct undesirable consequences such as it taking the physician longer to write an order, a tradeoff better tolerated by decision makers than by physicians. An indirect outcome might be that physicians may leave the organization because the implemented CPOE takes more time than they can tolerate.
Considering unanticipated consequences on the right side of the diagram, some related to CPOE are indeed desirable. An example of a direct one would be when a physician cannot remember the recommended drug, but, knowing there is one, deliberately enters the name of an appropriate but nonformulary medication so the system will alert him to the appropriate formulary choice. An indirect serendipitous outcome might be that by alerting him this way, the system helps the clinician to learn and remember the right drug so that he orders it the next time. An undesirable direct consequence of CPOE might be a decline in physician satisfaction. Another would be medical errors caused by the information system.

For example, a physician might order something for the wrong patient because of poor screen design. Finally, an example of an indirect unintended consequence would be physicians ignoring alerts because there are too many.

An important goal of this work is that once unanticipated consequences can be predicted, they move to the known side, the left side of the chart, because they are now anticipated. Another would be medical errors caused by the information system.

3.2. Further analysis of unanticipated consequences

Once the investigators had developed the Thematic Hierarchical Network Model, they analyzed each unintended consequence example from the data, attempting to categorize and understand each consequence. They further categorized the consequences by theme within the network model. Quotes given below are representative examples from interviews unless it is stated that they are from field notes. The authors have added explanations in brackets so that the context of the quote can be understood.

3.2.1. Desirable unintended consequences

Many of the desirable intended and unintended consequences relate to exam room computing. The benefits are associated with the physician–patient interchange with a computer in the room. From field notes done during exam room computing observation: “he then turns the patient instructions on the screen to the patient and they go over it line by line, clarifying any questions. Patient finds an error in the Premarin dose written on the screen and it’s changed.” A clinician noted that a patient will often ask “do you have my record up in front of you?” This clinician concluded: “I think they’re being more savvy.” In another exam room observation “with the first patient he uses it in the exam room only to have her help him with the content of a letter to her landlord.” Cooperative charting and composition seem to be serendipitous activities that go beyond the original purposes of CPOE implementation.

3.2.2. Undesirable direct consequences

These are the unintended consequences mentioned most often and of most interest because it is important that they be understood so that they can be prevented, considered tradeoffs, or overcome. They are roughly divided into errors and security consequences.

- Error concerns
Concerns were expressed in interviews about the possibility of errors being caused by the EMR. Observers saw order entry errors being corrected, so to the best of our knowledge these problems did not cause patient harm. The pharmacy usually received and corrected erroneous orders. From field notes from observing in the pharmacy: "on one occasion, a single morphine order was entered by the physician as oral liquid when in fact what was desired was injectable. the drop down for order route, the first route selectable for this strength was oral liquid." In another instance "an order for Effexor (an antidepressant) was entered as QID (four times a day) when what was intended was QD (once a day)." The pharmacy both detected and corrected these problems on a regular basis. Such juxtaposition errors, errors caused by close proximity on the screen, were also made as we watched clinicians enter orders. From field notes of observation of a physician: "she says 'oops, I just ordered it for X and I wanted it for Y!'" One user said "you just have to double check, you know. that's what you're supposed to do but I know people get fast and that's when errors are made." Also from field notes: "she tried to show me that epigastic was not on the coded list, but misspelled epigastric and did not recognize the misspelling and then with some indignation said 'see!' when the system returned no matches." In actuality, the system would have accepted the term if it had been spelled correctly, but she had no faith in the system.

- **Potential security concerns**

  A number of instances reported by observers concerned security. From field notes: "the terminals in the common nursing area were always in a logged-in state... users complained about time to secure and then re-logon." The nursing area is quite secure, so the problem here is not a serious one. However, securing the terminal in the exam room is an important issue. From another set of field notes from observations in an exam room: "he then put his cursor on 'secure' and turned away as he clicked the mouse. Unfortunately, the cursor moved and missed the 'secure' button, leaving the terminal open as he left the room."

3.2.3 Undesirable indirect consequences

Issues related to alerts, workflow, and ergonomics were often mentioned or observed to have negative consequences that were indirect.

- **Issues with alerts**

  There were numerous complaints about getting too many alerts or alerts at an inappropriate time: "Now we get alerts when we go to charting, which in my workflow is the last step. It's after the patient's gone. Now I get warned they've got some drug interaction. Great!" In general, however, at this site we heard far fewer complaints than elsewhere.

- **Workflow issues**

  There were a number of indirect consequences affecting workflow. For example, from field notes: "There seems to be a lot of duplication of work here, writing all the information on paper, putting it into systems, printing the patient instructions." One physician said quite eloquently "It pushes the throttle of professional life... it drives the speed of your existence forward." A nurse was sad that the doctors started "having to work through their lunch hour... they used to actually take a break and socialize." A support staff member stated that extra effort had to go into trying to make up for that loss of social opportunity: "facilitation of the social conversations was very felt as facilitating the training of how to actually learn how to type and how to actually enter an order."

  An interesting impact of exam room computing on the workflow of computer support staff was also noted: "sometimes there's a patient in the room and I don't feel comfortable just going in there [to fix a computer] and this poor man or woman was in there."

- **Ergonomic issues**

  Ergonomics were mentioned several times. One person noted: "it's not ergonomically friendly. I have chronic shouder pain." Someone else said ergonomics training would be beneficial. "when you're doing so much so fast... what's the best position? For people coming into it, [training] might prevent injuring from overuse."

3.2.4 Two sided consequences: both desirable and undesirable unintended consequences

Because of the complexity of consequences and because the model in Fig. 2 forces a strict categorization of instances that are not always clearly either desirable or undesirable, we found it difficult to classify many of the consequences. The impression that the consequence was desirable or undesirable changed by participant group, i.e. MD, RN, etc. and sometimes also by individual within a group. Several examples show how hard it is to categorize consequences: one user stated, "I am glad the computer goes down sometimes, otherwise I will forget how to use paper." This user was describing it in a positive way, but one might also say that the computer going down is an undesirable consequence that this person is viewing with great tolerance. In another example of a two sided consequence, a clinician noted "It was in some ways an equalizer... everybody could see a clinician's notes... a one word sentence or a complete evaluation." While that person viewed it as a desirable outcome, some clinicians may not regard this kind of visibility as positively. Finally, one nurse noted, "the more you know about the computer the better you are at your job." While she meant it as a desirable consequence, others might argue that it should not be such an important and visible factor in doing their job well.

- **Workflow issues**

  There were several workflow consequences that could be viewed in a plus or minus sense depending on your perspective. One clinician noted: "you can see where your weaknesses [in workflow] are." Someone else said "workflow is not something you learn about in medical school and you know most of it was sort of a level of unconscious incompetence." From field notes: "When the printer hums either the concerned person or one of the medical assistants picks it up... they have included the printer in their work routine." In some ways, however, it seems undesirable to depend on a hum to alert someone to a new order.

- **Interpersonal issues**

  There were also some interpersonal unintended consequences that are simultaneously desirable and undesirable. One person described the advantage of having a certain
degree of tension within the group that planned the implemen-
tation: “We were responsible for making it a success or failure and I’m convinced now when you get that tension it’s not necessarily a bad thing, there were certainly some heated moments but there were also some treasured times.”

- Reimplementations
A large group of examples that straddle the desirable/undesirable unintended consequences fence are concerned with “reimplementations,” which are system upgrades or replacement systems. In the case of Clinics Northwest, there have been numerous upgrades over the years as Clinics personnel worked with the vendor to make improvements. Data gathering there ended just prior to a major system upgrade. There was not a great deal of anxiety about reimplementation here. As one clinician noted, “the more you use it, the more comfortable you get with it.” A trainer stated “there’ll be a lot of positive people saying ‘oh this is great’ and then a lot of people saying ‘why do we have to change it again? What we had before was fine.’” So I think it’ll be mixed emotions.” Another trainee’s perspective was: “They get both technical support and constant training so it is easy for them to catch up with periodic system upgrades.” There has actually been a history of users clamoring for system upgrades. An implem-
ter stated, “We were rolling it out [in one of the clinics] and halfway through we actually decided to stop [because the product was not mature enough] and clinician leader-
ship said ‘no—we know there’s these limitations and we want to move forward [anyway].’” Users seem to recognize that the tradeoff for new functionality is that they will need to adapt. One user said “We actually drove most of the changes but it is hard to keep adapting.”

Users were aware that change was on the horizon; “We knew a big change was coming because it’s different enough they’re actually gonna put us into a sort of fifty percent mode [reduction in number of patients to see] for a few days.” There are some who are quite hostile towards any upgrade, however: “they break it every time they try to improve it...you assume the whole system will be useless for two weeks...it’ll freeze, it’ll break down, it will crash, things that used to work don’t work any more.”

4. Discussion
This study was limited in its covering only one site, although methodological rigor was maintained in other ways with its being multidisciplinary, multmethod, long term, and part of a multi-site study.
The Diffusion of Innovations model as depicted with the consequences loop seems well suited for describing the iterative nature of CPOE implementations. They are often upgraded, or reimplemented, in either minor or sometimes major respects. It seems that with each upgrade, there are concomitant unanticipated consequences. With each implem-
tation, participants remodel existing workflows, usually in a relatively unguided process to reach new, relatively sta-
bile work processes, generating consequences along the way. With reimplementations, those new workflows are disrupted, generating an entirely new family of consequences.

The consequences we studied varied greatly in level of severity, granularity, direction (positive and negative), source, and frequency of occurrence. The development of the The-
matic Hierarchical Network Model helped guide the analysis effectively. There were many “two sided” consequences, those that had both positive and negative aspects, which are indica-
tive of the complex nature of these clinical systems. These could justifiably be categorized within the network model in more than one place. For example, a system upgrade might be categorized as having anticipated, desirable, direct con-
sequences at the same time it has anticipated, undesirable, direct consequences.

5. Conclusion
The detailed analysis of examples of unintended conse-
quences indicated there were some desirable unintended conse-
quences in addition to undesirable unintended conse-
quences. There were error and security concerns, and issues related to alerts, workflow, ergonomics, interpersonal rela-
tions, and reimplementation. Even in a highly successful organization using clinical systems optimally, there are unin-
tended consequences since not all outcomes can be foreseen. As more research is done about unintended consequences and more lessons are learned and shared, we can better under-
stand the nature of unintended consequences. Once unin-
tended consequences are better understood, more will be fore-
saible and strategies can be outlined for preventing them, mitigating them, or overcoming them completely.

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