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Extending the understanding of computerized physician order entry: Implications for professional collaboration, workflow and quality of care

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ABSTRACT

Objective: To describe the perceived effect of computerized physician order entry (CPOE) on professional collaboration, workflow and quality of care. *Design*: Semi-structured interviews with experts involved in the design, implementation and evaluation of computerized physician order systems in the United States. *Measurements*: The interview transcripts were analyzed using six key concepts that identify context, professional collaboration, workflow and quality of care. *Results*: The interviews reveal the complexity of CPOE. Although providers enter the orders, others collaborate in the decision-making process. There is a profound impact on workflow beyond that of the provider. While quality of care is the main impetus for implementation, it remains terribly difficult to measure the impact on quality. *Conclusions*: A proper understanding of CPOE as a collaborative effort and the transformation of the health care activities into integrated care programs requires an understanding of how orders are created and processed, how CPOE as part of an integrated system can support the workflow, and how risks affecting patient care can be identified and reduced, especially during hand-offs in the workflow.

1. Introduction

Computerized physician order entry (CPOE) is defined as a process that allows a physician to enter medical orders directly and to manage the results of these orders. The concept is receiving an increasing level of attention because the Institute of Medicine notes that CPOE holds potential for decreasing the number of medical errors in health care organizations and recommends full-fledged implementation [1]. The Leapfrog Group – a coalition of over 150 public and private organizations providing health care benefits – has echoed this plea by recommending that hospitals introduce computer systems to computerize drug prescribing and that they be rewarded for it [2]. The California State Health and Safety Code, Section 1339.63, requires the introduction of technology, such as CPOE, that has been shown effective in eliminating or substantially reducing medication-related errors, in all California hospitals by 1 January 2005.

In reality, the implementation of CPOE has been problematic. In a recent survey, Ash et al. found that less than 10% of the US hospitals have implemented CPOE, a figure even lower than the results of an earlier survey by the same authors [3,4]. Several case studies describe how physicians have opposed CPOE for different reasons, such as the amount of time spent at the computer and concerns about clerical work that fall outside of their professional practice [5–8].

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Order communication is a highly collaborative process. A case study by Goorman and Berg suggests that the notion of interdependence in work is a key feature in creating medical orders and that nurses play an active role in entering medical orders in computerized systems [9]. Gorman et al. contend that the model of health care delivery underpinning CPOE is too naïve and suggest a model of distributed cognition among professionals to understand the creation of medical orders in a collaborative environment [10]. In a study about communication among health care providers in the ICU Pronovost et al. found how a daily goals form – developed to improve a common understanding of the daily goals of therapy – was associated with improved patient outcomes [11].

High-level CPOE experts recognize the difficulties with getting CPOE systems to work in everyday health care settings. This paper reports results of interviews with these experts to combine their rich experience and insights with theoretical insights from medical sociology and the field of computer supported cooperative work (CSCW). The goal is to enhance the general understanding of CPOE implementation and use. More specifically, the notions of professional collaboration and workflow are core themes in this understanding. A proper understanding of these themes is a *sine qua non* to reap the full benefits of CPOE technology in health care work.

The experts have been selected from among attendees of a consensus panel meeting to identify principles for the successful implementation of CPOE; the first and second authors took part in this meeting [12].

2. Extending the understanding of CPOE

CPOE systems have primarily been designed with the tasks and responsibilities of individual physicians in mind and implementation efforts have been primarily targeted at them. Goorman and Berg, however, argue that the model underpinning CPOE contains a projection of medical activities that does not match the activities of physicians as they actually take place on a ward [9]. In their study of order creation, Gorman et al. also suggest that the implicit model underlying CPOE does not take account of its collaborative nature [10]. In these models, orders originate with a physician, who enters them into a system. Then the orders are transcribed and distributed to various departments, and are translated into executable functions such as lab tests, medications, treatments or other procedures. Health personnel then carry out these procedures that together comprise the patient care that is provided (see Fig. 1). Such views often simplistically present medical work as a fixed sequence of steps based on the rationality of the scientific method.

Many scholars have explored the collaborative nature of medical work. In a classic study Strauss et al. describe how the delivery of patient care can be characterized as managing a patient illness trajectory that includes the total organization of work done of over that course [13]. The authors contend that decisions about patient care are not made by a single individual but are the result of "negotiations" of health professionals, sometimes even including the patient and his/her family. They argue that this concept is necessary for a sociological understanding of illness management preventing the researchers

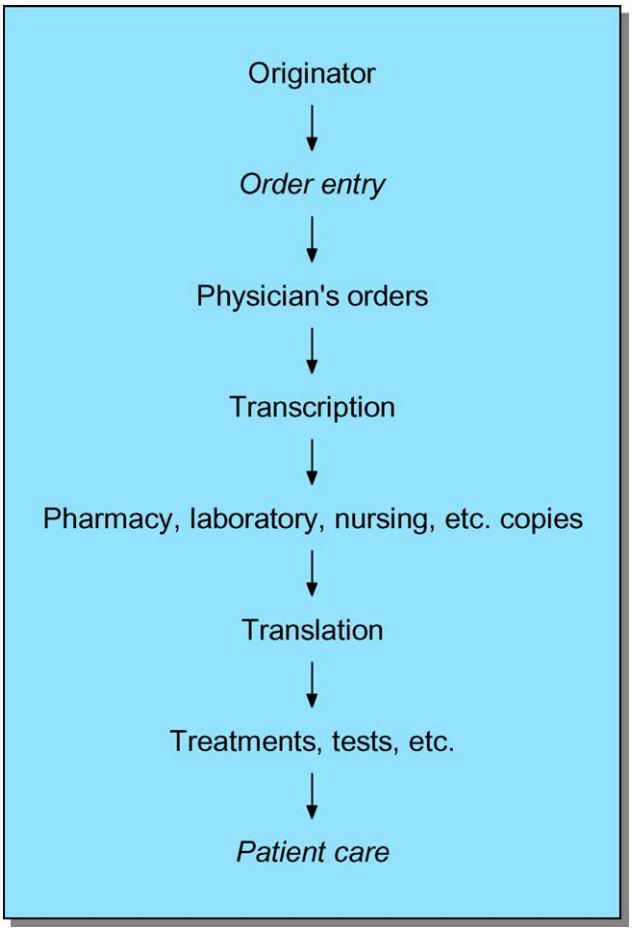

Fig. 1 – Processing of physician orders after Gorman. This is a very simplified, linear model that does not take account of complexity of the CPOE workflow. Much of the understanding of CPOE is directed on the order entry part. Each of the subsequent steps is less understood. Each of the hand-offs in the workflow is a potential source of errors.

from being confined by simplified models of medical work and workflow found in most medical textbooks. The authors base their concept on close observation of health care professionals through seeing, hearing, and interviewing. Berg builds on this understanding by arguing that systems design and implementation should take into account the fluidity of the process and the content of medical work [14]. He also argues that in practice, boundaries between tasks and roles of health professionals are not so tightly drawn.

Pratt et al. argue that medical work, because of its inherent collaborative nature, can benefit from design and implementation methodologies from the field of computer-supported cooperative work (CSCW) [15]. In the 1980s, CSCW emerged as an interdisciplinary field that examines how computer systems can be instrumental in reducing the complexity of coordinating cooperative activities, individually conducted and yet interdependent [16]. Østerlund found that seemingly inefficient practices of duplicating or reduplicating patient data in different documents (whether on paper or in the form of information systems) in a patient trajectory are in fact instru-

mental to coordinate medical work activities among different professionals [17]. From these findings emerges a picture of patient care that by its very nature is supported by collaborative work practices. CPOE as a collaborative effort is involves the notion that order creation and processing are a result of professionals, physicians, nurses, and the patient making collaborative decisions about patient care.

This study addresses the following research questions:

- What are the perceptions of high-level experts about professional collaboration and workflow and how they impact the quality of care?
- What are the implications of the findings for the understanding of CPOE?

2.1. *Professional collaboration*

Decisions about medical care are integral to managing patient trajectories and result from a process of often implicit negotiations among stakeholders, including the patient [13]. Knowledge about the patient's illness and treatment is distributed among the participants in the trajectory. Creating and processing medical orders result from the interaction of physicians, nurses, other health professionals and sometimes the patient managing a patient trajectory. In a landmark ethnographic study of navigation work on a US military vessel, Hutchins found how cognition is distributed across the members of the navigation team, how this distributed cognition is different from individual cognition, and how the meaning of messages pertaining to an understanding of the situation is negotiated among the members to achieve a navigation goal [18]. Hutchins argued that his findings are valid for any type of teamwork aiming at some common goal. Goorman and Berg described how in a Dutch hospital the implementers changed a CPOE system designed for physician medication order entry. By facilitating nursing input, they restored the distributed way of manual medication ordering in which these nurses had always played a pivotal role [9]. In a study about order creation and communication in an ICU, Hazlehurst et al. showed how complex the interactions and the flows of information between the actors are. They described the pivotal role of a secretary making sure that a medical order is carried out as desired [19]. The number of studies about the complexity of order creation and communication are still very limited, but the studies mentioned above suggest that the models of medical work underlying CPOE may be too focused on the individual cognition and behavior of clinicians. Order entry, rather, has to be conceptualized as the result of a process in which the distributed knowledge about a patient problem helps the group members to interactively achieve a common goal.

2.2. *Workflow*

In the routing of the medical order many different professionals are involved, including nurses, pharmacists, physiotherapists, radiologists and lab technicians. This routing includes the order creation and communication process, and also the processing of the order at the receiving end and the returning of the results of an order result. For example, a physician or a nurse may enter a medication order, but then a pharmacist will check the dose and process it and the order will be returned in the form of a medication sheet for the nurse and a prepared dose for dispensing to the patient. Similar routings can be identified for other types of medical orders, such a lab orders. Health IT applications such as CPOE systems will typically support such routings through conceptualizing these steps as part of a workflow: a linear sequence of circumscribed activities, to be executed by sharply identified agents, within which each activity creates necessary input for the next step in the workflow. Both the concepts of professional collaboration and workflow have the notion of the involvement of multiple individuals, but the first emphasizes the synchronous and interactive aspect of getting work done.

In a study about the effects of CPOE on ICU workflow, Cheng et al. showed how the actual workflow with many feedback loops deviates from the idealized workflow [20]. The authors found, for example, that nurses frequently conversed with physicians about medical orders and that a pharmacist modification often results in a second medication sheet printed at the nursing station. In addition, only parts of the medical order workflow are supported by CPOE systems. Other parts, such as drug dispensing by pharmacy and drug administration by nursing are often supported by systems that are sometimes connected to CPOE systems by interface protocols [21]. For example, automated drug dispensing cabinets containing tailored patient dosages are becoming more common. However, these machines are not always integrated with CPOE systems. This means that in the overall medical ordering routings, many hand-offs still pose a risk for the quality of the ordering process. In the words of Brown and Duguid, workflow in health care is not a linear, step-by-step process with clear-cut inputs and outputs and sharply targeted information needs. Rather, in health care, the 'workflows' require many interactions between the activities and their "owners" that in reality are not sharply demarcated at all [22].

2.3. *Quality of care*

Implementation of CPOE has been recommended to reduce medical errors and increase the quality of care [23]. Evaluation studies of CPOE implementation in hospitals in the 1970s and 1980s showed economic savings and also better patient outcomes in terms of reduction in length of patient stay and improvement of the quality of medication orders in terms of legibility, completeness and decrease of transcription errors [24]. Later studies were fully focused on medication errors and adverse drug events. Kaushal et al. reviewed the effects of CPOE and clinical decision support systems on medication safety and concluded that CPOE significantly decreased medication error rates [25]. But the evidence is based on a limited set of clinical studies (two controlled trial studies, two observational studies with controls and one study that employed both designs). Much less is known about medical errors throughout the entire workflow process, but a study by Berman suggests that most medical errors occur during dispensing (53%), administration (24%) and then prescribing (15%) [26]. Several strategies have been recommended to reduce errors, such as the use of bar coding technology and automated dispensing systems [27]. However, Oren et al. show that the evidence that these technologies reduce medi-

cal errors and adverse drug events is very limited [28]. Reason et al. point out that there is a risk that technological solutions to increase patient safety may be focused too much on individual behavior and they may ignore organizational behavior [29]. Several studies suggest that physicians in particular are not aware of the systemic nature and size of the problem [30]. There is anecdotal evidence that physicians often blame each other about making mistakes and assert that it does not apply to them. Also, many errors are corrected in the workflow without the ordering physician becoming aware of it.

The issues raised in the three previous paragraphs suggest that efforts to improve patient safety and the quality of care should also focus on occasions that may disrupt the fine fabric of professional collaboration and the workflow involving many different professionals.

3. Research methods

To extend the general understanding of CPOE, this research focused on the perceptions of experts about professional collaboration, workflow and quality of care. In October and November, 2003, the first author conducted 16 semi-structured interviews with 17 experts involved in CPOE implementations (see Table 1). The experts were partly selected from the participants in the first consensus meeting on the success-

Table 1 – List of interviews conducted with 17 experts involved in CPOE

Interview no.	Interviewed person	When	Role in CPOE	Affiliation	Key topics of interview
1	Physician	October 2003	Medical director clinical information systems	Community hospital chain	CPOE implementation strategy in non-teaching hospital setting; physician role
2	Physician	October 2003	Medical director clinical information system	Health maintenance organization	Implementation strategy of CPOE; quality systems
3	Physician	October 2003	User, researcher	Health maintenance organization	User perspective of CPOE
4	Medical informatics scientist	October 2003	Researcher; director of applied research	Health maintenance organization	Research on CPOE; design strategies
5	Pharmacist	October 2003	Pharmacist, implementer	Community hospital chain	Pilot implementation CPOE; pharmacist's role; back end of CPOE workflow
6	Nurse	October 2003	Project leader CPOE implementation	Community hospital chain	CPOE implementation strategy in non-teaching hospital setting; physician role
7	Software specialist	October 2003	Software designer CPOE	Vendor	CPOE product development; customer relations
8	Physician	October 2003	Medical staff leader information systems	Academic medical center	Implementation strategy
9	Physician	November 2003	Project leader medical record system, user	VA medical center	Implementation strategy; user support
10	Hospital management executive	November 2003	Chief information officer	Community hospital	Health care strategy; IT-strategy, CPOE implementation strategy
11	Two physicians (double interview)	November 2003	User (hospitalist), developer, implementer	Community hospital	Use of CPOE; user support; implementation
12	Nurse	November 2003	Coordinator CPOE	Community hospital	Development; user support
13	Physician; associate professor	November 2003	Clinical researcher, medical user	Academic medical center	Decision support associated with CPOE; research on outcomes of CPOE and medical errors; quality systems
14	Physician; assistant professor	November 2003	Researcher, teacher	Academic medical center	User perspective of CPOE
15	Physician	November 2003	Quality informatics director	Academic medical center	Decision support associated with CPOE; research on outcomes of CPOE and medical errors; quality systems
16	Physician	November 2003	Researcher	Academic medical center, research institute	Design, implementation and use of CPOE; research on decision support

The experts included participants of the first consensus meeting on meeting on the successful implementation of CPOE systems and staff members of a community hospital and consisted of 11 physicians, 2 nurses, 1 pharmacist, 1 hospital executive, 1 medical informatics researcher and 1 software specialist. The interviewed persons represented 12 organizations (see Table 2). In each of the interviews the six domains (see text) were addressed. Depending on the expertise and experience of the interviewed person certain topics were emphasized. The key interview topics are listed in the last column.

ful implementation of CPOE in which the first and second authors participated [31]. The interviewees represented users, implementers, vendors and researchers. The first author also visited a community hospital that has been using CPOE for many years and interviewed an IT project leader, a hospital management executive, and two physicians together. In all, the interviewees represented 12 different organizations, which included five academic medical centers, three community hospitals, a VA medical center, a health maintenance organization, and a vendor. The high level of knowledge of the interviewees offered the authors an opportunity to explore CPOE issues in-depth.

The duration of the interviews varied from 30 min to 1 h and 15 min and lasted on average 50 min. The respondents received by e-mail a brief note that explained the purpose of the study and listed six topics that would be addressed during the interview. They were:

- the description of the CPOE system in use and history of the implementation;
- the users of CPOE and their involvement;
- organizational impact on medical work;
- redesign of the CPOE workflow;
- patterns of collaboration at order creation;
- effects on quality of care.

The first three topics were meant to provide the context of the involvement of respondents with CPOE systems. The last three topics were central to the research questions.

Table 2 – Main characteristics of the organizations of the interviewed persons

Organization no.	Interview no. (see Table 1)	Type of organization	CPOE system	Physician employment status	Physician use	Main characteristics
1	1	Community hospital chain	Vendor system	Self-employed; hospitalists employed	Physicians involved in planning and pilot	Planning and pilot phase
2	2, 3, 4	Health maintenance organization	Vendor system	Employed	Full physician use	CPOE part of integrated medical record system
3	5	Community hospital chain	Vendor system	Self-employed; hospitalists employed	Physicians involved in planning and pilot	Planning and pilot phase
4	6	Community hospital chain	Vendor system	Self-employed; hospitalists employed	Physicians involved in planning and pilot	Planning and pilot phase
5	7	Vendor	Array of products, including clinical applications	Not applicable		Several CPOE systems fully implemented in hospitals; phasing into new product line
6	8	Academic medical center	CPOE planned for the future	Employed	Not yet applicable; physicians involved in planning	Medical director of information systems has strong CPOE experience
7	9	VA medical center	Vendor system	Employed	Full physician use	CPOE system part of integrated computerized patient record system
8	10, 11, 12	Community hospital	Vendor system	Self-employed; hospitalists employed	Full physician use	Current system being phased out and replaced by state-of-the-art system of same vendor
9	13	Academic medical center	Homegrown system	Employed	Use by residents and house staff	Strong research base
10	14	Academic medical center	Vendor system	Employed	Use by residents and house staff	
11	15	Academic medical center	Vendor system	Employed	Use by residents and house staff	
12	16	Academic medical center	Homegrown system	Employed	Use by residents and house staff	Strong research base

Most hospital organizations have implemented fully functional CPOE systems. Three community hospital chains are planning for such systems and are conducting small-scale pilots.

Details about the interviewed experts, their backgrounds and key topics discussed are listed in Table 1. The interview transcripts were analyzed with the help of Atlas 4ti, a software application for qualitative text analysis, using the last three topics listed above as units of analysis.

The study was approved by the Institutional Review Board of Oregon Health & Science University as part of the "Physician Order Entry: Field Study of Success Factors (National Library of Medicine grant LM06942-02)."

4. Results

The interviews resulted in 269 typewritten pages (single line spacing, A4 paper format). We will now briefly highlight some findings from the interviews focusing on context, professional collaboration, workflow and quality of care. The context encompasses the first three interview topics; and they are not listed separately. Organizations described in this section are those associated with the interviewees.

4.1. *Context*

All university medical centers represented by these interviewees have implemented CPOE systems that have been in place for about a decade. One community hospital has had a CPOE system operational for three decades. The other community hospitals are planning to implement CPOE, have contracted with a vendor, and are already conducting pilots. The VA medical center and the health maintenance organization in this study have implemented CPOE as an integral part of their electronic patient record systems. The vendor represented by an interviewee has a large installed base of clerical and clinical systems, but its CPOE product is operational in less than 10 hospitals. Two academic medical centers represented here have developed a strong research base for CPOE related clinical outcome studies. The main characteristics of the organizations are listed in Table 2.

Though one community hospital, the VA medical center, and the health maintenance organization have acquired widely available systems, their involvement with the design and implementation was such that these systems were essentially homegrown. The users and system designers collaborated intensively on location to develop and improve the CPOE system. All respondents from organizations using CPOE indicated that implementation lead times are on the order of three years or more up to the moment that a substantial number of physicians are using it. All implemented systems have the order entry piece; few of them are really integrated into comprehensive systems that cover the complete workflow including pharmacy and drug dispensing. The implementation of CPOE is seen by all as quite complex.

The respondents from organizations that have implemented CPOE all mention a high degree of physician use. None of them, at the time of the interviews, had made CPOE use mandatory, but they created conditions that left physicians very little choice. For example, the medical director of the health maintenance organization explains that over 95% of the physicians do order entry because of a policy that only physicians can sign off medical orders: "It is not a written policy [to do computerized order entry], but it is the general policy."

The community hospitals that are planning to implement CPOE systems cannot be so sure that physicians will enter their own orders electronically. The interviewees from these hospitals fear that physicians will consider such a task as clerical and they emphasize their prudent methods for involving them. Their physicians are not employed by the hospitals, but they have, as part of large medical groups, agreements to send their patients to the hospital. If they are unhappy with one hospital, they can sometimes send their patients relatively easily to another. The CPOE project leaders focus on physicians who can be considered as early adopters and they try to identify immediate benefits for them – such as making their workflow more efficient and appealing to their pride in providing quality care – and by trying not to upset them by making CPOE use mandatory. They expect that peer pressure will bring other physicians on board. Nurses are often much more involved in the medical ordering process than physicians are. In these hospitals, nurses are very involved in handling medical orders, sometimes guided by clinical protocols and guidelines. Even so, CPOE pilots are placing the physician in the foreground. In teaching hospitals, which include the academic medical centers and the VA medical center, it is common to delegate medical order entry work to house officers. Entering medical orders is seen as part of their training. It is much more difficult to do that in community hospitals, which usually do not employ residents.

In order to increase physician use of CPOE, the community hospitals are seeking to involve hospitalists who are employed as primary care physicians or internists by the hospital or the contracted medical group. In the hospital they take routine care on a 24-h basis of the patients sent in by private physicians. After explaining the pilot test in a rehabilitation unit, a medical director of clinical information systems in a community hospital describes the implementation strategy this way: "So after we do rehab, we're gonna go after the hospitalists. And the hospitalists are internists that are paid by the hospital, so they're hospital employees. Then we're gonna go after the house staff. They're residents. Then we're gonna start rounding with private physician groups one by one, but by then we'll have the house staff and the residents on it, so if it hasn't worked for the hospitalists and the residents then we pull the cord on the project. If it has worked for them, then we can use them to sell it to the other physicians." The medical group associated with the community hospital that is known for its high physician involvement in CPOE employs hospitalists for taking a care of the hospitalized patients belonging to the group, and they thus accept a large part of the burden of doing order entry.

The respondents in the organizations that have implemented CPOE all indicated that physicians have made electronic order entry part of their work life and found it hard to compare with the situation before. However, ongoing changes in the CPOE system may still affect medical work practices. For example, in the health maintenance organization, workstations are now being installed in the exam rooms. Up to this point, order entry would take place in the physician's office after the patient had been seen. The physician would take notes on a piece of paper and then bring that to his office

and do the order entry. Taking notes and rereading gives the physician the opportunity to reconsider his decision-making and alter his decisions if necessary. Introducing the workstation in the exam room would allow immediate order entry if this fits the physician's individual workflow.

4.2. *Professional collaboration*

None of the interviewees from institutions that have implemented CPOE described explicitly the problem of the complex decision-making that precedes order entry. There is nevertheless a distinction between the stage before entering the order, during which people interact and decide what to do, and the act of entering the order itself. The physician enters the order because he or she is best able to appreciate and interpret the suggestions of the associated decision support system.

For the respondents who are implementing CPOE in community hospitals, the explicit and implicit roles that nurses play in creating orders are an issue. When preparing a CPOE pilot in a hospice unit of a community hospital, the project pharmacist found that nurses and physicians had developed ways of working with pain medication orders that allowed liberal bounds for dosing. It was perhaps the small size of the group which made "everyone comfortable with each other's work and therefore [they] had a pretty liberal, had a lot of leeway to do what they felt was necessary for the care of the patients." He observed that it turned out that it was difficult to use the structured format that computer entry really requires.

The chief information officer of a community hospital, on the other hand, expects that CPOE will facilitate the introduction of clinical paths, for cardiology for example, and that having clinical paths will require more explicit collaboration between physicians and nurses and that their collaboration will be supported by clinical guidelines and protocols.

4.3. *Workflow*

The respondents all agree that redesign of the workflow needs to be addressed more adequately. Most of the work on CPOE was until recently mostly focused on the order entry part and the associated decision support because of the intrinsic complexity of implementation. A clinical researcher of a teaching hospital that has implemented CPOE comments that "CPOE is a big project, and doing each of the back end links is quite time consuming. So it is not an unreasonable approach to do things, for example, just to put in the front-end and perhaps put in a little link to pharmacy and then to say that we are gonna go back later and do the links to the other ancillaries later on." A director of quality informatics who has been involved in CPOE implementation projects in other academic medical centers acknowledges that "many people even in a sophisticated health care institution think explicitly about what are the processes, you know, the fact that there is a decision-making process, and that the physicians execute their orders and then the nurses take off their orders and some of those things get routed to the lab and some of those things get routed to pharmacy and some of these things get routed to radiology and then the radiologists take over, and that, if you wanted to improve something you would target various aspects of that process."

Three issues emerged. First, there is the possible lack of understanding in hospitals about how IT relates to workflow. The software specialist reported a case in which a hospital wanted to have CPOE in first and then add charting, ignoring that orders might get lost because nurses would have no way of knowing whether an order was in. She suggested a careful rethinking of each step in the workflow, assessing what technology would need to come first and then deciding about CPOE before it becomes the "dark ordering side of the loop."

Second, there is a concern how the roles of the participants in the workflow would change. The same software specialist reported a case of a communication breakdown in which, after implementation of CPOE, nurses were not informed about orders and could not initiate interventions because the doctors entered all orders themselves. The project pharmacist reported the role of the pharmacist in verifying orders. In most CPOE implementations, the pharmacist would still verify orders and get back to the physician if he felt that the order was incorrect or inappropriate. Introducing advanced decision support in CPOE might reduce the role of pharmacist to mere dispensing. However, the pharmacist's role might actually become broader. According to the project pharmacist: "...but also at a more general sense being able to look at the entire picture and see if there are some omissions to a patient therapy or if some therapies appear to be redundant, you know, and that's a more of a bigger picture role. And there have been several publications in the last few years about the value of pharmacists in patient rounds, ICU rounds; I think that's a role that they are going to be transitioning in to as POE continues to roll out."

The third issue concerns the notification process. Before CPOE implementation, nurses would know about medication for patients before the order went to the pharmacy and they could start to prepare for dispensing almost immediately. A CPOE project leader summarizes the problem: "So one of the big hurdles that we are trying to identify and meet is this sort of new order notification process. How does the nurse know, or anybody know, when there are new orders in the system. Currently, they are written, the nurse actually or the ward clerk or unit secretary actually enters them into the computer, so that is when they know. If it is CPOE, the physician can either be entering those orders in on the unit, they could be on another unit, they could be in their office or indeed they can be at home, entering an order. So, that whole new order notification process is a big change with CPOE, and we have done things to get the nurses with a sort of electronic notification, electronic alerts to counteract that sort of thing."

4.4. *Quality of care*

The positive effects of CPOE on reducing medication errors, publicity about the IOM reports on patient safety, and the subsequent stream of reports by consulting firms about the necessity of CPOE and the current level of implementation, were the most important reasons why hospitals implement CPOE. They recognize that the number of scientific studies is limited and that the results of the Brigham and Women's Hospital and Regenstrief Institute studies are hard to extrapolate because of the poor replicability. However, as the hospital executive noted: "Key to us is patient safety initiatives."

Apart from the respondents from the academic research institutions, none of the respondents who had implemented CPOE had any direct proof of improved quality of care. In the health maintenance organization and the Veterans Affairs medical center implementations of CPOE systems, the quality of care was very much associated with their preventive medicine and public health emphases. Because the orders become part of the electronic medical record, the physicians were able to flag patients for check-ups and special treatments. According to interviewees, this integrated functionality improves patient outcomes.

5. Discussion

Not surprisingly, several dimensions of complexity of CPOE implementation and use emerges from the interviews. First, implementation is a thoroughly social process in which the roles and responsibilities of health professionals are changing. Second, CPOE needs to fit the workflow, which is not always well understood. Third, evidence of a positive impact on the quality of care is still limited. The results of this study are consistent with theoretical insights from the sociology of medical work and the design of systems supporting collaborative work.

5.1. *Professional collaboration*

The role of the physician is key to CPOE implementation because the physician is expected to be responsible for entering orders. Implementation efforts focus on strategies for involving physicians. In the academic medical centers, house officers (residents and fellows) enter orders as part of their training, supervised by their superiors. Another strategy is to design system features in such a way that they are only useful for physicians. The major concern about physicians interacting with CPOE systems is that they take additional time, confirmed in a study by Doolan and Bates [32]. Many efforts are therefore made to adapt the system such that physicians can do the task faster or that the value of the information they get from the system compensates for time lost. Respondents from community hospitals that are planning to implement CPOE systems want to maintain good working relationships with self-employed community physicians. They are concerned about the future role of nurses who entered medical orders on behalf of physicians. There is a trend toward hiring more hospitalists—primary care physicians and internists who are employed by medical groups or hospitals to take care of patients in the hospital on a 24/7 basis. Hospitalists seem to do most of the computerized order entry tasks and, like house officers, they are employees, so their use of CPOE can be mandated. A review of the hospitalist movement estimates that currently 7000 hospitalists are employed in community hospitals across the United States and that their number will grow to 19,000 [33]. One can infer from these figures that hospitalists will play a key role in CPOE, and will ease the problem of involving self-employed physicians.

The growing shortage of health care personnel will probably also increase the need for delegating tasks, including drug order entry, to highly qualified professionals such as nurse practitioners. In the UK, specialized nurses are authorized to prescribe drugs in defined circumstances using a tailored formulary and special guidelines and protocols [34].

The observations of the respondents parallel findings of Strauss et al. that patient care can be characterized as group work [13]. Gorman et al. concludes from a study of physician order entry in critical care that an approach focused on the outcome of the medical decision and the entering of the order in the system ignores the complexity of group work in which the medical order comes into existence [10]. According to Gorman et al., group work appears to facilitate sense making and involves mutual construction of understandings over time. Despite the focus on physicians' use computerized order entry, different professions are very much involved as well. While in teaching hospitals the burden of order entry is carried by residents and house staff, an increasing number of hospitalists fulfill a similar function. This tendency will probably not change the group work and nurse's role that is so essential in creating orders. A proper understanding of CPOE in different health care settings requires an understanding of order creation as a complex professional collaborative process at the point of care.

5.2. *Workflow*

A narrow focus on order entry results in both an overly linear and also fragmented view of the workflow. The problems are threefold. First, and closely tied to the previous point about professional collaboration, the roles, tasks and responsibilities of different professionals are in practice much less clearly circumscribed than they are taken to be by many system designers [22]. Second, changes in these roles, tasks and responsibilities of different professionals remain mostly implicit and not clarified. For example, when decision support becomes an integral part of CPOE, will the role of the pharmacist be reduced to merely dispensing the drugs? Or when the pharmacist has a key role in assuring the quality of medication ordering, how will that affect workflow? Or should the role shift towards counseling the physician, helping to develop guidelines and protocols, and taking part in clinical rounds? Before introduction of CPOE, the nurse would often know immediately that an order was being written. Now the nurse needs to be notified electronically, which raises the questions about when that will happen and how that will happen. From the interviews a picture emerges that many solutions to these problems are quite ad hoc. Third, many different information systems that are not integrated support parts of the CPOE workflow. For example, when a medication order arrives in the pharmacy, it may be entered and verified in a system that is not connected to the order entry system, and the medication might then be packaged with a barcode label and processed in a different system for dispensing.

The IOM report envisages a health care system that supports continued improvement in the six aims of safety, effectiveness, patient-centeredness, timeliness, efficiency and equity [23]. The services in such a system are "coordinated across practices, settings, and patient conditions over time using increasingly sophisticated information systems." In this vision CPOE should be part of an integrated IT system fully supporting the continuum of care. This requires a transformation of the delivery care system into care programs with

measurable outcomes, integrated planning, restructuring and delegation of tasks, and IT supporting the process of care. As a hospital executive observed: "Other industries would never allow the fragmentation to occur that occurs in health care. The automotive industry, the finance, I mean, they just, it is all about consolidation and dis-intermediating all that crap from happening, right? We have allowed intermediations and hand-offs to happen, and quite frankly, when you think about it, that is why health care doesn't deliver at the level that it can. Every hand-off is an opportunity for failure."

5.3. *Quality of care*

Research on the benefits of CPOE in preventing medical errors has mainly been focused on the order entry piece and on the individual behavior of the physician. All respondents quote these studies and the recommendations of the IOM and interested groups such as the Leapfrog Group as the main reason to implement CPOE and expect that their organizations will see dramatic improvements in the quality of care. According to Bates et al., the benefits of CPOE derive for the most part from physicians interacting with decision support [35]. The studies, however, seem to ignore the collaborative nature of health care work and the fact that order entry is part of a complex workflow. According to Hutchins, many errors in group work are corrected through the interactions of the actors and group performance seems to protect against errors or failures of individual members [18]. Hutchins argues further that the individual response to errors results from mutual learning, allowing newcomers to adopt explicit and implicit rules set in the group. These findings imply that similar mechanisms should be found in health care work when it is seen as a collaborative effort. The question needs to be asked whether and how computerized decision support will be able to substitute for the safety network that characterizes current practices of creating and entering orders collaboratively.

While at the point of creating and entering orders the synchronous characteristic of professional collaboration may be important, Hutchins' arguments also holds true when considering workflow, where time sequential, asynchronous activities across organizational boundaries (within or outside a hospital) are dominant. The use of different information technologies in the workflow such as order entry systems, pharmacy systems, and dispensing systems adds another degree of complexity that can be a serious source of errors and failures. Analyzing the workflow to reduce errors and improve the quality of care can lead to the next step of rethinking the workflow. According to Groth, the revolutionary impact of IT is that it makes possible new coordination mechanisms and thereby new forms of organization [36]. The interviewees from the health maintenance organization described how their information system enabled them to design targeted programs for patients with specific health problems such as diabetes. The information system, which is an integration of an electronic medical record and a physician order entry system, allows identification of patients who have been diagnosed with, for example, diabetes, use of order sets and assessment of disease specific outcomes. Introducing CPOE requires integration not only at the system level, but also at the level of patient care. The example of the health maintenance organization shows how the integrated approach allows a change from order management that centers around order creating, processing and retrieving results to program management in which activities are planned, integrated and organized towards disease profiled patients. The next step then for improving quality is to create care pathways, to examine the roles are of the actors in the pathways, and to assess how CPOE might fit into such concept.

5.4. *Limitations of the study*

This study has several limitations. First, the selection of experts may be biased because they were chosen from among the participants of an invitational consensus meeting. However, the potential for bias was minimized because of the variety of their professional backgrounds and their organizations and because the semi-structured format of the interview was consistent in all interviews. Second, the data obtained about CPOE were largely self-reported, although the contents were verified by comparing data from multiple sources.

6. Conclusion

The interviews show a rich picture of CPOE that includes practical issues of use and implementation and policy issues related to organizational strategy and changing health care practices. The interviewees acknowledge the complexity of integrating those issues into a comprehensive approach. But the next step might require the abandonment of accepted truths, such as the belief that only a licensed physician can enter orders and that this will therefore increase patient care quality. As one informant noted, if you focus on a subatomic task to increase patient safety you may well decrease patient safety in the overall process of care. For example, the current uncertainty about introducing CPOE in community hospitals could be turned into strength if hospitals and medical groups work together to create patient care pathways across organizational boundaries and examine how information technology might fit in such a concept for increasing the quality of care. An increasing number of hospitalists are being hired to provide the continuity of care and they are becoming instrumental in the implementation of CPOE.

Extending the understanding of CPOE then translates in an understanding of care pathways and addressing the question how CPOE might fit into such a model. Care pathways can be analyzed through observational methods. Insights from CSCW may help to design and implement CPOE in a collaborative environment.

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