

Computerization and Information Assembling Process: Nursing Work and CPOE Adoption

Xiaomu Zhou

School of Communication and
Information, Rutgers, State University
of New Jersey, U.S.A.

xmzhou@umich.edu

Mark S. Ackerman

School of Information, Department of
EECS, University of Michigan
Ann Arbor, Michigan, U.S.A.

ackerm@umich.edu

Kai Zheng

School of Public Health, School of
Information, University of Michigan
Ann Arbor, Michigan, U.S.A.

kzheng@umich.edu

ABSTRACT

This paper presents an ethnographic study investigating how nurses assemble information to start their shift's work. We examined this process before and after the adoption of a Computerized Prescriber Order Entry (CPOE) system in an inpatient unit of a large teaching hospital. Before the CPOE adoption, nurses used several collaboratively-created group working documents to assist in this information assembling process; after the CPOE adoption, they mainly used the CPOE itself for their information needs. We found while computerization facilitated medical data assembling process and improved order handling practice, it also resulted in some information gaps in understanding patients in their larger care context. We analyzed what it means when the computerization of medical information turns local knowledge into more readily available and public information objects, as well as what that means for patients and patient care.

Categories and Subject Descriptors

H.0 [information systems]; K.4.3 [organizational impacts]:
Computer-supported cooperative work.

General Terms

Documentation, Design, Human Factors, Theory

Keywords

Personal sheet, working document, shift change, electronic medical records, CPOE, CSCW, information system.

1. INTRODUCTION

In this paper, we examine information use in healthcare organizational settings. We approach this topic from a distinctive angle through investigating 1) how nurses assemble information from several locally-created group documents to construct their personal working sheets; and 2) how this practice is affected by the adoption of Computerized Prescriber Order Entry (CPOE).

Briefly speaking, a CPOE system allows authorized prescribers to

write medication orders and transmits the orders electronically to pharmacies, labs, procedure departments, and nursing. In the current healthcare reform climate in which strong emphasis is placed on increased and meaningful use of health information technology, CPOE plays a central role in modernizing inpatient care facilities to improve quality and patient safety.

However, due to the complexity of medication management in inpatient care and relatively immature technology designs for addressing this complexity, prior evaluation studies have reported numerous unintended adverse consequences associated with adoption of CPOE, resulting in diminished quality of care and escalated patient safety risks [e.g., 6, 10, 14]. These detrimental effects are generally attributable to problematic human-machine interfaces, oversimplified workflow models, disrupted power structures among clinicians, and unexpected changes introduced to the patterns of team coordination [19]. In this paper, we aimed to contribute to the literature through a close investigation in how introduction of CPOE affects nurses' information assembling processes.

The conceptual development reported in this paper originated from our field work conducted *before*, *during*, and *after* a CPOE implementation in the empirical setting. In one of our earlier studies, we analyzed how nurses, as a group, collaboratively create and maintain working documents and use them to coordinate work both within and across work shifts [20]. In this paper, we focus on this information assembling process at the level of individual nurses, especially after the CPOE adoption.

The rest of the paper proceeds as follows. In the next section, we present a brief literature review of prior studies related to how information is used in organizational settings. In section 3, we describe the empirical setting and data collection methods. In section 4, we present our findings on how nurses' information assembling behavior differs before and after CPOE adoption. In section 5, we discuss what this change means. The paper is rounded off with practical implications and some concluding remarks.

2. BACKGROUND

An important research stream in Human-Computer Interaction (HCI) and Computer-Supported Cooperative Work (CSCW) concerns information use in organizational settings—how individuals in groups use information to accomplish their work and how a group collaboratively creates a common information space to facilitate information sharing [3]. The CSCW literature about information in health organizations has explored the processes of creation, exchange, and use of nursing information

Permission to make digital or hard copies of all or part of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. To copy otherwise, or republish, to post on servers or to redistribute to lists, requires prior specific permission and/or a fee.

IHI'10, November 11–12, 2010, Arlington, Virginia, USA.
Copyright 2010 ACM 978-1-4503-0030-8/10/11...\$10.00.

[16]; the role that ‘informal’ information or ‘transitional artifacts’ play in supporting cooperative work, particularly work-in-progress [7, 9, 20]; and, why information redundancy in a healthcare environment is not only necessary, but sometimes crucial, to facilitate coordination and articulation of collaborative work [5, 12]. The tendency to formalize work with a technological solution, while neglecting the importance of ‘informal’ types of information, may also create new problems [9, 20].

In the context of CPOE adoption, prior research has identified various issues resulting in suboptimal outcomes. Research to date about the impact of CPOE on medical order practice has provided us with general knowledge regarding workflow changes, task rearrangement, expertise reallocations, workarounds, and various unintended consequences [10, 14]. For instance, patients’ medication-related information has been found to be fragmented, and as a result, extra coordinative activities are often needed to perform order tasks in computerized environments [13]. Remarkably, while nursing work is arranged around order administration [18], CPOE systems are often physician-centered by design; while they facilitate information flows from physicians to nurses and pharmacists, they also decrease the flows in the reverse direction [13]. Further, research has suggested that CPOE adoption can introduce disruptions to clinical workflow, decreasing clinicians’ time efficiency and compromising the extent and quality of physician-nurse and physician-patient interactions [2]. Furthermore, other studies attribute various newly-devised informal interactions and practices (including workarounds) to decreased communication between nurses and physicians in a post-CPOE operation [15]. As well, due to the additional time needed to use a CPOE, nursing activities and care planning have also been found to be significantly reduced with CPOE adoption [2].

In this study, we aim to explicate the impact of CPOE adoption through the lens of individual nurses’ information practices. More specifically, we want to explore how nurses assemble various data about their patients at the beginning of each shift to create a memory aid for their work, how this information assembling process has been altered as a result of CPOE adoption, how this change might improve or affect the acquisition of their knowledge about patients, and what this change means to the quality of patient care.

The analysis of this paper, focusing on a specific information assembling process with its micro-level detail, was inspired by Ackerman and Halverson’s hotline study [1] and Tellioglu and Wagner’s study of software engineers [17], both of which consider the ecology of information practices surrounding work activities. In this study, we are interested in examining how changes introduced to the work environment which may seem trivial, could bring with them significant information gaps prohibiting healthcare workers (nurses primarily in this context) from developing a comprehensive understanding of the conditions of and treatments for their patients.

3. ABOUT THE STUDY

3.1 Observation Site

This paper reports on a field-based study of an internal medicine unit of a large academic medical center in a Midwestern state. The first author observed nursing activities for 18 months, including a continuous eight-month period of time in 2008. In the fifth month during the eight-month observation period, a CPOE system was

introduced into the study site. This provided us an opportunity to examine the changing nature of information use before and after its introduction.

The nursing unit occupies one section of a medical center floor, with two hallways surrounding one nursing station in a center location. For each shift, there are two teams working on two hallways, taking care of 32 patients at the unit’s full capacity. There were computers in all of the patient rooms in addition to the nursing conference room, medication room, report room, satellite stations, and staff center.

Many patients admitted to this unit have chronic episodes of their illness across their adult life-span and come to the hospital when they experience a flare-up or other acute situations, such as arthritis, asthma, diabetes, hypertension and heart disease, and gastroenterological problems. In addition, this unit often takes patients who attempted to commit suicide through drug overdoses. Even though some of these patients may need to be sent to the psychiatric unit eventually, they are admitted to this internal medicine unit to rule out any possible medical situation. Therefore, the nurses may have to deal with patients who have some emotional issues. Furthermore, there have been an increasing number of patients with various kinds of pain issues which are not directly related to their original chronic illness. Many of these issues are caused by, or contribute to, serious psychosocial problems.

3.2 Participants

Our observation covered the entire nursing unit. Organizationally, the unit consists of 1) one nursing manager, who is the top lead of the unit administratively, 2) one administrative assistant, who mainly deals with nurses’ scheduling issue and assist manager, 3) one nursing specialist, who ensures the nursing interventions are made appropriately with doctors’ treatment plan, 4) 56 registered nurses, 5) 19 nurses aids, and 6) seven clerks. About 90% of nursing staff works fulltime, and this has not changed after the CPOE adoption. Among the 56 staff nurses, one senior nurse takes the role of clinical supervisor, who maintains the authority to make decisions on all nursing care issues. Two other senior nurses act as education coordinators.

3.3 Information Objects

There is a huge ecology of information objects that the nurses must use every day. The information objects include eCare¹, an internally developed electronic patient record system, a 24Hour Patient Flowsheet, medical orders prescribed by the doctors, special specimen forms, reference books, whiteboards, audio tapes, and various working documents. There was also a Medication Administration Records (MAR) system, which was completely replaced by eMAR in the CPOE.

This paper will extensively discuss four working documents:

- The personal working sheet (hereafter referred to as a PS). The PS allows a nurse to assemble her patients’ information (e.g. basic medical condition and ongoing treatment), which serves as a memory aid and handy artifact throughout her entire shift, and is used to track her patients ongoing care activities.

¹ All names in this paper, including the electronic medical records system, patient, and clinical personnel names are pseudonyms.

- The Assignment Sheet (hereafter referred to as an AS). An AS includes brief information about all 16 patients (in one hallway) for which a team is responsible. Nurses use it to coordinate and assist each other when needed.
- A nursing Kardex. A nursing Kardex summarizes a patient's illness and some of her critical ongoing medical orders. This existed only prior to the CPOE adoption.
- The Shift Report Sheet (hereafter referred to as SRS). The SRS document records a summary of doctors' notes, newest lab results, and nursing care information about a patient. This existed only prior to the CPOE adoption.

Both the nursing Kardex and the SRS worked as a group working document: Each nurse contributed to the generation of the information and also benefited from the content that other nurses entered.

3.4 Data Collection

This is an extensive field-based observational study. In addition to field notes, the first author also collected over 200 copies of the four different types of nursing working documents and reviewed over 400 nursing documents on-site during the observations, which allows an in-depth analysis of the document content. She also conducted numerous informal interviews with nurses, audited several nursing leadership meetings at which the launch of the CPOE system was discussed, and conducted 12 formal interviews.

We use grounded theory [8, 11] approach to allow more focused and specific themes to emerge. The first author periodically wrote analytical memos based on the field notes, then discussed them with her co-researchers to further guide the field investigation. For the study reported in this paper, we extracted the portions from our observational notes that were related to how nurses construct their PSs for data analysis. In addition, the actual PSs collected allowed us to examine how nurses wrote down the information in its original context. The field notes, collected documents, and interviews were used to corroborate one another during the analysis.

4. INFORMATION ASSEMBLING

There are many aspects of nursing work, but mostly they can be categorized as patient care and documentation. In order to provide patient care, nurses need to first know about their patients. This information need is fulfilled by a complex process, including acquiring information from heterogeneous sources, such as patient records, working documents, audio tape, face-to-face communication, and so on. Our investigation focused on how various types of the information contributed this process, how the information was carried through difference sources, and how nurses created their PSs by accessing these sources. We wanted to understand what distinctive role each of these information sources played, and what effect the adoption of the CPOE might have on this process.

In the rest of this section, we first provide some baseline information about how nurses assembled information to create their PS *prior* to the CPOE. Some of the rich detail regarding to how several group documents (e.g. nursing Kardex, Assignment Sheet and Shift Report Sheet) were used in supporting information sharing, can be found in an earlier study [20]; here we report only a summary necessary to an understanding of how the

work changed. We focus below on how nurses currently work with the CPOE in constructing their PSs. To do this, we chose one among numerous cases we observed. The advantage of using one complete case to report general findings is to allow micro-level details to highlight nonetheless major issues observed in other cases [1].

4.1 Information Assembling prior to CPOE

Before the CPOE was introduced, nurses started their work with the shift change meeting. Depending on the shift (i.e. day, evening, or night), each nurse was assigned three to six patients and always received at least one total care patient, who often needed one-on-one attention. Nurses often arrived in the unit at least fifteen minutes before 7AM, 3PM, or 11PM respectively for the three different shifts. They took their stethoscope and writing instruments from their personal mailbox, the AS prepared by the outgoing nurses usually placed on the table of the conference room, and a piece of blank paper or template to wait for the shift-change meeting to start. (See Figure 1A for the physical location of each of information objects prior to the CPOE implementation.)

At the beginning of the meeting, the incoming charge nurse played the audiotape reports prepared by the outgoing charge nurse. This oral report contained information about all 16 patients on one hallway, and was mostly about what had happened during the last shift for each patient, the patients' alert and orientation status, any warnings about the work that needed to be done during the next shift, any unusual events during the last shift, and things might be occurring soon. The incoming nurses sat around the table in the nursing conference room, listening to the tape and taking notes for each patient on the AS to complement what had been already provided by the outgoing charge nurse.

The AS was a shift-based document including brief medical information about the 16 patients at any time on one hallway. It held each patient's room number, family name, diagnosis, activity assistance, treatments/IV fluids, vital signs frequency, I&O, CS/WT (chemstick/weight), specimens, and medical issues. Near the end of a shift, each nurse reported the workload issues about her patients to the charge nurse so the charge nurse could modify the AS used for next shift. Then the charge nurse made copies for each incoming shift member as a working document for team coordination. By reading information on the AS and listening to the tape report, incoming nurses knew how busy they would be for their shift as a team. If one nurse was caught up with a total-care patient, the other nurses on the team often took care of her remaining patients. From this perspective, the AS provided a very convenient reference in real-time—a nurse could easily take it out from her pocket as a quick reference before she went to see a patient who was not covered by her duty.

After the audiotape report, the charge nurse assigned patients to each incoming nurse based on the workload of each patient. The entire shift change meeting usually took less than 20 minutes. After the shift change meeting, nurses started to assemble their patients' information into their PSs. They pulled out their patients' nursing Kardex and SRS, which were folded together for each patient and collected in a big binder placed on the table. From these two documents, a nurse could find the different information she needed to understand her patients.

Next, we briefly introduce what information a Kardex and a SRS contained and how they were created.

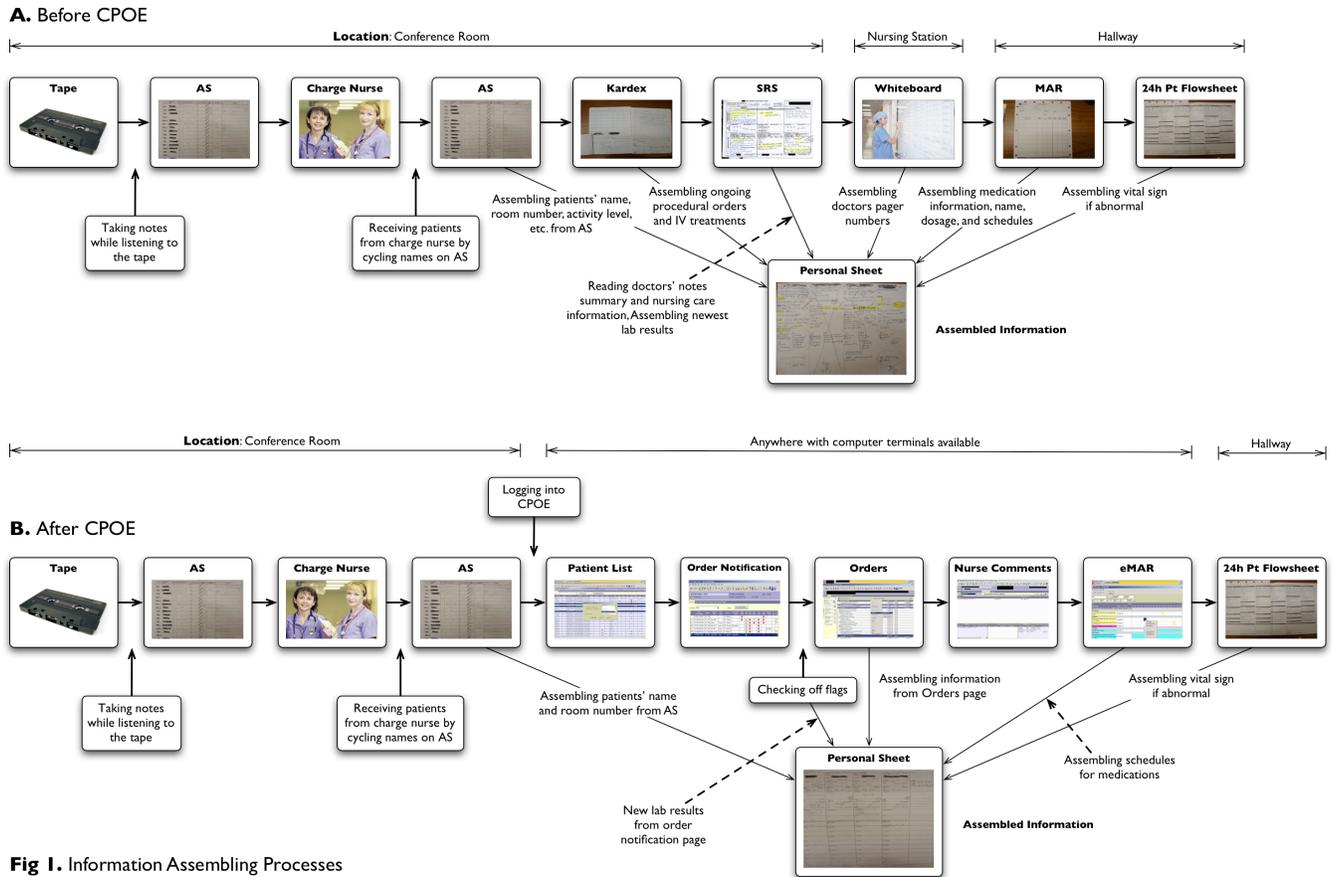


Fig 1. Information Assembling Processes

A Kardex is often used in nursing practice. In this unit, it was an A4 sized card that provided a quick overview of basic patient care information, including name, age, marital status, religion, allergies, diagnoses, brief orders information (mainly procedure, diet, IV therapy, tests), do-not-resuscitate status, consultations, permitted activities, functional limitations, and emergency contact numbers. Some items might be trimmed but the necessary information was always recorded. Nurses updated on-going procedural orders on a Kardex with pencils, so they could immediately erase it when an order was finished or discontinued. In this way, the Kardex always kept the most current medical care information. When a patient was admitted, the admitting nurse would create a Kardex for this patient, filling in basic information assembled from the eCare and by interacting with the patient. It was jointly modified by nurses in subsequent shifts during a patient's entire hospitalization.

To complement what a Kardex did not carry, one nurse from the unit invented the SRS six years ago, which was used to summarize doctors' notes about a patient's current illness, medical history, and progress as well as to copy the most recent lab results, both of which were stored in eCare. In addition, the SRSs also noted nursing care information. Each page of the SRS was produced by nurses on the day's three shifts; accumulatively, the SRSs recorded trajectory information about a patient. Prior to the CPOE, nurses did not spend much time with computers, so this collaborative-created group working document saved time for the incoming nurses over many following shifts. They could

easily know about a patient's general trajectory by flipping through the SRSs accumulated since her hospitalization.

The SRS included casually handwritten information. Side notes about the emotional needs and psychosocial issues of patients were one important category of information. Examples included "needy at times" or "see social worker and my note to get whole story." These notes not only conveyed workload-related information but also told an incoming nurse how to approach her patients. In addition, casual notes, such as "daughter very friendly/needy," were also a way to provide a richer picture of the patient's situation. This collaborative contribution seemed to suggest a collective pride in providing not only medical care but also emotional support. Even though the SRS might contain psychosocially sensitive information or judgmental words (e.g. "needy at times"), nurses felt comfortable writing those comments down because they believed it was good to let other nurses know. The SRS was kept for only several days during a patient's hospitalization and shared among only the unit nurses. The SRS for a patient was thrown out after discharge.

Nurses copied down ongoing orders from the Kardex and the most recent lab results from the SRS, and might also highlight warnings from these two working documents on their PSs. Outgoing nurses might also take the chance to talk with the incoming nurses face-to-face on issues that had occurred very recently and were not covered by the audio report.

After the information assembling occurred in the conference room, nurses would go to the nursing station center to copy

doctors' pager numbers from the whiteboard, and then they walked to hallway to assemble ongoing medication orders (paper-based) stored in the Medication Administration Records (MAR) folder. A nurse also might copy down her patients' vital signs, as documented on the 24 Hours Patient Flowsheet. Both of these information objects were part of the formal and permanent medical record and were placed at each patient's bedside². After all of this, a nurse was ready to see her patients for a first visit.

To conclude, the highest priority for incoming nurses in the first half hour of the shift was to take over the patients from the outgoing nurses. To get familiar her patients, a nurse assembled the necessary information to create her PS before going to see their patients. The information channels that contributed to the personal sheet included 1) audio tape, 2) AS, 3) Kardex, 4) SRS, 5) face-to-face conversation with outgoing nurses, 6) whiteboard, 7) MAR, and 8) 24 Hour Patient Flowsheet. (Figure 1A.) During the shift, nurses used their PSs to jot down significant issues that happened to the patient. Then they reported to the charge nurse or updated the information on the Kardex and SRS to inform incoming nurses. This entire process involved complex information assemblages that took place at both individual and collective level and which were seamlessly intertwined.

Next, we turn to the current situation to see how the adoption of CPOE has changed the way that nurses construct their PSs. See Figure 1 for an overview of workflow change along with digitized information objects.

4.2 Information Assembling post CPOE

Nursing work is arranged around the administration of medical orders prescribed by doctors. A CPOE system allows doctors to write electronic medical orders and instantly deliver to pharmacies, labs, procedure departments, and nursing. In addition to the electronic order management, the CPOE system in our study site was designed to attempt replacing all paper-based nursing working documents through a function entitled "Clinical Summary". In the CPOE, nurses were able to find information about a patient's health issues, significant events, and allergies, as what the Kardex originally carried. Furthermore, the "Comments" area on the Clinical Summary page was designed to allow nurses to note any concerns from a nursing perspective, replacing the SRS's "nursing plan of care" box. This box often included the personal and psychosocial information about a patient, and was used by nurses to know about a patient as a person. Because both the Kardex and SRS were replaced by the CPOE, the adoption of the new CPOE system inevitably changed nursing practice in many ways.

To illustrate the new practice, we use one representative case throughout the following sections to illustrate how one unit nurse, Joan, assembled information about her patient Ms. Watson at the beginning of her morning shift.

Figure 1B shows the graphical order of information objects Joan accessed in this process. Our interpretation is interwoven with the description of the case.

² Bedside referred to a fold-down shelf that holds the Patient 24 Hours Flowsheet and the MAR folder. It was mounted on the wall in hallways instead of the patient's real bedside; clinicians used "bedside" to refer the location of these two documents.

4.2.1 Receiving New Patients

Joan began by examining the AS for Ms. Watson. (The following quotes come from the field notes.)

It was 7am, Saturday. Joan sat before a computer, holding a copy of AS and a PS template. Three other nurses sat around the table and the charge nurse started playing the audiotape prepared by the outgoing charge nurse.

The original entry for the patient Watson on the AS was very simple, "Watson, (room) 433, chronic cough, ↑, HL, QS, ADA, QID, sputum."³

While short and simple, the AS entry for Ms. Watson told Joan that this patient's current diagnosis was a chronic cough; she could get up to walk without assistance; she had a Heparin Lock (for an IV treatment); her vital signs should be checked every shift; she was on a diabetic diet, and her blood sugar should be checked four times a day; and sputum should be collected. The AS described the patient's current diagnosis and had a very minimal description of the ongoing medical situation. As one of the nurses said, only "basic stuff, anything that pertains each shift" goes on the AS. As such, with only an AS entry, Joan might have gotten the impression that patient Watson was perhaps not a heavy workload patient and it was a pretty easy case. However, when she listened to the portion of the audiotape for Watson, Joan heard,

"Ms. Watson. This patient is A(Alert) O(Orientation) times three, and the vital signs are stable. She is under chronic cough. Her issue is that she can be really dramatic at times. And she will request more pain medication. MDs were at the bedside several times. They have warned us that they will not be ordering any more pain medications for her. She does receive Toradol every six hours IV, and that is helping a little bit with her pain. The patient, she claimed she had seizures but the MDs think this is made up. They think she also has some border line psych issues so she even has her own bed. She actually was o.k. for us on night shift and didn't have any episodes but as a warning she can't do that."

Joan was a bit surprised in hearing this, and made a note on the entry for Ms. Watson on her AS, "dramatic @Xs, Ø more narcotics, per pt sz hx – MD deny? Psych."

Indeed, the AS entry alone was not able to convey a full description about Ms. Watson. As one can read from the tape transcript, the charge nurse depicted a richer picture, which was largely based on the outgoing night shift nurse's oral report. This was particularly important for an incoming nurse to understand: Ms. Watson might have some potential behavioral issues and conflicts with the doctors, as because the doctors did not believe what Ms. Watson reported about her "seizure" experience. It warned the nurse that the patient would not get more pain medication.

Nurses were often proud of themselves in advocating for patients; however, they have to follow doctors' orders. Ms. Watson's situation implied a difference in understanding between the doctors and the patient about the presented illness, which would put any nurse who took care of Ms. Watson in an awkward

³ A sputum sample refers to the mucus coughed up from the lower airways. It is usually used for microbiological investigations of respiratory infections.

situation. During the tape playing, Joan had not yet received the patient assignment. While she was not sure she would receive Ms. Watson, she still noted several key pieces of information on her AS as a reminder that psychosocial issues might be a major concern for this patient even though the medical issue might not be critical.

After the CPOE implementation, for various reasons (see [20] for more detail), nurses have become hesitant to enter nursing care information (particularly the psychosocial information) in the “Comments” area on the CPOE Clinical Summary page, as was intended by the system design. Instead, nurses have tried to make the tape report longer, so as to include the sensitive, psychosocial, or problematic issues such as Ms. Watson’s case. However, this oral channel is good only from one shift to the next, not across multiple shifts: An outgoing nurse tended to report what had happened during her shift instead of the cumulative information that the original SRS carried from multiple shifts.

The case continues:

After the entire tape report, the charge nurse spent about 7 minutes to make the assignment. Joan received four patients, including Ms. Watson. Then, she immediately started to construct her PS. She quickly copied all of her four patients’ room numbers and names from the AS onto her personal sheet, and carefully noted the diagnosis, activity level, diet, and vital sign check frequency. Then she logged into the CPOE.

It is worth pointing out that Joan in fact did not copy her short note about psychosocial issues of Ms. Watson on the AS into her PS. Indeed, as below we will describe, the PS served as a to-do list for Joan, as it did for other nurses we observed. It is also worth pointing out that the psychosocial information learned from the audiotape contributed enormously to a better understanding of the patient and of the situation, such as the conflict between doctors and patient in Ms. Watson’s case.

Next, we describe how Joan used information from the CPOE to continue her PS construction.

4.2.2 Working with CPOE

After logging into CPOE, Joan located Ms. Watson. She first went to her “Orders” page. Under the very top category, “Admit/Discharge/Transfer”, Joan was able to find various information she needed to know, such as allergy, diet, weight, diagnosis, service code and doctor’s pager, and so forth, so she copied them all into her PS. Joan could not find the patient height information, so she marked “HT” over the weight data on her PS as a way to remind herself that she needed to find out about the patient’s height and entered it into the system.

Joan and other nurses were very happy with the automatic assembling done by the CPOE. On the top of the “Orders” page, she could find almost all the medical data she needed to fill in her PS. These data were originally carried in multiple information objects (e.g. Kardex, AS, whiteboard) in the prior paper-based environment.

After this basic medical data assembling, Joan wanted to know more about overall orders as well as nursing care information:

Joan skimmed other orders and then clicked the Clinical Summary page, hoping to find some nursing care

information about Ms. Watson. However, she only found out one entry - “allergy precaution”. Then she quickly jumped onto “eMAR” page, which showed the scheduled medication and was also used to record medication administration results. She circled 9:00, 12:00, 13:00, and 14:00 on her PS as a way to remind herself that she needed to administer medications for Ms. Watson at these specific times.

This constitutes a big shift in Joan’s work. Previously with paper-based orders, Joan always wrote down the medication names and dosages and then circled the time on her PS as a way to remind herself of the tasks she needed to do. The PS was also used as a mechanism to double-check her work before giving the medication to the patient. Officially, nurses were not supposed to copy medication orders onto their PSs, because they might copy something incorrectly and create medical errors. Instead, nurses were encouraged to bring MAR folder (which contained the official paper print-out of ongoing medication orders from the hospital pharmacy) with them into a patient’s room as a reference to double-check.

However, nurses did not want to bring the MAR folder into a patient’s room because it was often very bulky (with a hardcover protection and an accumulation of all medication orders since the patient’s hospitalization; the MAR might contain bacteria harmful to the patient, since it was usually placed on a fold-down shelf in the hallway; and moving the folder in and out of a patient’s room could spread dangerous bacteria. Because of these concerns, even though not encouraged by official policy, Joan, together with many other nurses, always first reviewed the MAR and then copied medications onto her personal report sheet.

With the CPOE in place and after computers were installed in all patients’ rooms, the medication room (which stored patients’ medications), hallways, the conference room, and the nursing station center, nurses could access medical order information in real-time almost anywhere. So, there was no longer a need for Joan to copy this information onto her PS. In fact, she only reviewed the eMAR, and circled the times as a reminder. The color-coding of eMAR highlighted medications in their various statuses, which provided Joan an easy way to figure out what medications were ongoing, what was being used as-needed, what was delayed, and so forth.

It should be noted that it took Joan quite a few months to reach her comfort zone, so as to not copy medication information (names and dosage) over onto her PS. She had been doing this for many years since she practiced nursing as a way of knowing what medications each patient was prescribed. Her traditional practice was finally replaced by the ease of real-time access to review orders at almost any location on the nursing ward.

4.2.3 Face-to-face Interaction

As mentioned, sometimes the outgoing nurse spoke directly to the incoming nurse:

While Joan was preparing her PS in front of a computer, the outgoing nurse, Beth, who took care of Ms. Watson for the night shift came into the conference room. She talked with Joan about some further issues with Ms. Watson. Apparently, at 6am this morning, Ms. Watson woke up with her hands shaking, asking for pain medication regarding to her cough and pain. Beth told Joan that the doctors had made it clear that they did not want to be paged; however, Ms. Watson

demanding to have Dilaudid (, a strong addictive and abusable pain medication). While listening, Joan nodded. She quickly finished the information assembling on PS for her all patients and started her first visit to Ms. Watson.

Face-to-face interaction is always very powerful in communication. In this case, however, since Joan had already learned the problematic situation about Ms. Watson during the tape report, Beth's story did not surprise Joan. Still, this information provided Joan with a further understanding of Ms. Watson's most recent situation and how her shift might be with this patient: She might run into a very problematic situation. Apparently the doctors did not want to be paged while the patient insisted on wanting stronger pain medication. Joan had to satisfy both sides. As in the previous section, Joan did not write down this story into her PS. Indeed, this information gave her a better understanding of and warning about the situation rather than serving as a to-do task, as were many items on her PS.

Indeed, as we examined Joan's PS after she finished her shift, most of the items she wrote or circled at the beginning of her shift had been crossed off. For her, constructing a PS was now to create a to-do list for each of her patients. Throughout the shift, she crossed off tasks as she finished them, one by one, as she described herself, "I am a 'cross it off the list' kind of person."

4.2.4 What Is Missing

Throughout the information assembling process for Ms. Watson, Joan accessed several different information channels including the AS, audiotape, CPOE, and outgoing nurse. Joan did not read the patient medical history stored in doctors' admission notes in the eCare system. In fact, she did not do this for her three other patients before she went to visit them. Previously, she would have read doctors' notes as summarized by previous nurses and carried via the SRS. As observed in the case, by the time she finished her PS preparation, it was already past 7:50AM. According to her, she always wanted to see her patients at least ten minutes before 8AM. She was under time pressure to review all four patients' information and assembled that information into her PS.

Prior to the CPOE adoption, nurses did not necessarily have the time to get on eCare to read doctors' notes after a shift-change meeting as well. However, they could get a brief description from the previous nurses' summary of doctors' notes, which was carried on the SRS. Along with accumulative nursing care information, also documented on SRS, nurses could get a nice picture about who the patient was and why the patient was in the unit. In our observations after the CPOE adoption, we saw only a couple of senior nurses consistently trying to read the eCare notes during the information assembling for their PS, even though doing so significantly delayed visiting their patients. Among them, one commented,

"I know I am slow, but what's the point if you do it [getting on eCare to read patient's overall medical history] later?"

The other nurse said,

"Just because I like to go in there, instead of being blank, not knowing a *thing* about the person. I got the heads up what this person is going through ... So when I see them, I can talk something other than illness that I can relate to, 'Oh, you are a sea captain!' ... Something unusual. That, they are very happy to share ... So, patients feel better, knowing I know something."

This raises the question: what is the minimum information that a nurse needs to know in order to provide patient care? Was the information on the SRS indeed necessary? Nurses agreed that as long as they knew the ongoing orders they could start their work; for other things (e.g. patients' illness trajectory, emotional needs, personality), they felt they could always catch up later during the shift. This was consistent to what we have observed: Some nurses' initial PS may only have very little information, i.e. name, diagnosis room number, and scheduled time for medication orders.

In a formal interview, Joan was asked to compare how well she was able to assemble information before and after the CPOE adoption to serve any need to understand patients. She sighed,

"I feel that there is more personal stuff that is passed along through Kardex and (SRS)."

The researcher asked what "personal stuff" meant and Joan replied:

"About the patients. In many ways, it's a great loss. We don't have those little things (i.e. Kardex and SRS) any more. On the whole, CPOE saves tons of the time, because I am not going [to have] to try to figure out doctors' scribbles [of orders]: I often had to [hold] doctors handwritten orders upside down in order to figure out what they wrote. It wastes time and it leaves room for errors. Now it's faster and it's safer."

Joan's comments were confirmed by quite a few nurses. While appreciating the positive outcome of the new technology, they were indeed aware that the nursing care information, particularly psychosocial information originally documented on the SRS and the in-depth knowledge about the patient, had partially disappeared.

4.2.5 What is Gone

With the adoption of CPOE, some of the group assembling processes was automated by the new system. For instance, nurses no longer need to write summaries of doctors' notes or copy new lab results onto their SRS. There is a super link that connects eCare with the CPOE, and nurses do not have to write ongoing critical IV or procedure orders on a Kardex anymore because the Orders page in the CPOE displays all orders with various filter functions. This was celebrated by the nurses due to the huge reduction of the documentation burden. As intended, the only group practice that remained after CPOE was to jointly document nursing care information in the Comments area on the Clinical Summary page, the part of the common information space [3] designed for nurses to facilitate information sharing. However, as we showed in our earlier study [20], nurses have not utilized that area well. The important group documentation practice for local knowledge sharing has switched to largely an individually-oriented oral report to the charge nurse and then from the charge nurse to incoming nurses.

While each individual nurse quickly adjusted her way of constructing the PS after the adoption of CPOE, we are puzzled by why once the group documentation practice was gone, it never came back. After two years of the CPOE adoption, the Comments area is still largely underused and no new form of documentation (either paper or electronic) has been created to replace the loss of the valuable nursing care information previously captured in SRS.

5. DISCUSSION

The prior description illustrates the dual processes of constructing PSs prior to and after the CPOE adoption. It provided an interesting case of how computerization of medical information not only changes the way nurses assemble information but also the nature of local knowledge practice.

What does this change mean? How may this change affect a nurse's knowing about her patients?

The biggest difference is that majority of the nurses no longer write down medication names and dosages; instead, they only circle the scheduled time for medications. This is an intended outcome of the CPOE adoption. As mentioned, both the technology affordance of a real-time access to review orders in the CPOE and hospital policy have ensured and enforced this better practice.

However, the difference in medication information on the PS may not reflect the full change from before to after the CPOE adoption. The purpose of information assembling had been not only to produce a PS, but also to contribute to a nurse's *knowing* about her patients, even though this knowledge may not have been written onto her PS. To understand the difference that occurred, we must take a close look at the information objects used and the sequential order in which nurses assemble information within both processes.

Prior to the CPOE, nurses used a number of local information objects to help them assemble information into their PSs, such as audiotape, AS, Kardex, SRS, and whiteboard. They were local not only because they were locally created but also they contained substantial *local knowledge* that was only meant to be shared within the unit. The accumulated information contributed by each nurse, particularly on the SRS, conveyed a very rich picture about a patient and a shared understanding of the patient's illness experience. It contained "personal stuff", allowing nurses to know their patients as a person rather than just their illness. In addition, it also embedded group wisdom, such as when a nurse might realize a seemingly cranky patient could be easily cheered up by humoring him, she noted this tip on SRS to share with other nurses. Likewise, SRS also let other nurses know, and share responsibility, about patients, such as warning one another about patient hiding medicine potentially for illegal use.

In addition to the local knowledge, SRS also included substantial publicly available information. It included a summary of doctors' notes and the newest lab results in eCare, which provided nurses an up-to-date picture of the patient and also a larger context of why the patient was here and how the current illness or other related medical condition had been managed in the past, i.e. trajectory information about a patient. As well, the Kardex gathered all ongoing procedure orders and IV treatments at the nursing station. Nurses re-arranged these components into a piece of paper, making it handy in the conference room, so they could access it while sitting around the table during the shift-change meeting. The easy accessibility of the components, with their fit to nursing work, and the time-savings explained why these assembled objects were able to assist nurses' information needs prior to the CPOE. Different representations of the same information, carried by different records and media [1], could help further the nursing work, which explains why nurses created these information objects at the first place.

The CPOE successfully automated the publicly available information and gathered the information originally in various documents and records into one place. As we have seen, nurses mainly use the CPOE to construct their PSs (with copying only the room number and the patient's name from the AS and sometimes abnormal vital signs from the 24 Hour Patient Flowsheet).

However, the nurses feel that "personal stuff" about patients is missing in this new process, which creates a hole in their knowing about the patient. The effort and attempt in the design of CPOE to provide a common information space [3] for the unit nurses to share nursing care information was under-appreciated, because it essentially ignored the nature of local knowledge and made that local knowledge public to everyone in the hospital. The resulting visibility and the politics of this information in the new system held nurses back from contributing their knowledge of patients to others. Of course, they could still share some of this information through the oral report or sometimes face-to-face interaction; however, the oral channel is less systematic and cannot present a trajectory of information as an accumulated written record would present. Again, having information and including it in the record are different; in fact, it makes huge difference for the knowledge collection and information reuse [1].

Another gap in the post-CPOE process is in *knowing* a patient in a larger context *before* nurses go to visit their patients. As described, the CPOE indeed provides a super link for nurses to access eCare and then, with just a couple of clicks, to read doctors' notes, so the nurses could know about their patients' in their larger care context (as opposed to having only the current diagnosed illness). However, as we discovered, other than a couple of nurses who routinely access eCare to review doctors' notes during the construction of their PSs, the majority of the nurses do not take advantage of this feature. They may get on eCare to find out more about patients *later*, but that is usually over half-way through or close to the end of the shift, shortly before they stop taking care of a patient. (Nurses often do not have the same patient the next day.) Why?

We believe the sequential order of accessing information objects may make the difference. Previously, right after receiving the patient assignment, nurses who sat around the table could access the Kardex and SRS within an arm's distance, since these two documents were stored on the table. The nurses pulled them out, briefly copied ongoing procedural and IV treatments (if presented) onto their PS, and flipped through a stack of SRSs, which provided them with both rich nursing care information and the doctors' notes about the patients giving a larger context. Assembling the significant medication orders took place after the nurses left the conference room and traveled to each patient's MAR folder located in the hallway, which stored a patient's medication information.

After the CPOE, right after they receive their patient assignments, nurses immediately get on the CPOE to review the Orders pages and eMAR schedules. The first category (i.e. Admit /Transfer /Discharge) of the Orders in fact provides nurses most of the *medical* information about the patients: diagnosis, diet, vital sign / blood sugar check frequency, admitting doctor's pager and service code, and so on. The nurses quickly copy all this information onto their PSs, review non-medication related orders (i.e. procedural and lab orders), and then quickly jump into the eMAR page, which tracks how the medication orders are to be administrated and whether they are on time. As described above, when the

nurses are under time pressure, which seems to be always true, they skip the chance to read doctors' notes before they visit patients.

Indeed, nursing work is arranged around order administration. Administering medication (including IV treatments) on time is perhaps the first priority for them to focus on. The CPOE reinforces this practice by recording the results of medication administration with a hard time stamp in the eMAR. We do not know whether there is a clear way to measure a nurse's work, but many nurses do not want to have too many delayed order administrations in their performance records. These delays are automatically captured in the CPOE system. Previously in paper order system, a five-minute delay in medication administration would not mean so much to nurses; however, it would mean much more in such an automated system. As our investigation shows, nurses said that as long as they knew the orders prescribed by the doctors they could start their work, and so they began.

In this situation, *knowing* a patient better becomes a marginalized concern. With the CPOE, it becomes each individual nurse's preference whether she wants to know patients more than just seeing their illness diagnosis and ongoing orders when she goes to see her patients. Previously in the paper-based environment, it was a group practice that everyone would read the SRS around the table in the conference room to get a sense of the patients' information and trajectories. It is true that our study alone does not have the evidence to claim there is any clinical outcome difference from the new patient care with its different level of knowing patients. However, given that patients can have over twenty medications in two hours, among which some are prescribed for other, co-morbid chronic conditions, one may assume that knowing patients within their fuller and larger context would enable nurses to understand why certain medications are prescribed for this patient in the first place. Knowing the patient may help nurses catch potential medication errors, provide more pleasant care, and prepare for emergency situations that might occur during the current hospitalization.

6. IMPLICATIONS

By analyzing how nurses assemble information to support nursing care activity and how this practice changed due to the adoption of a CPOE system, this study suggests several implications from theoretical, design, and practical (i.e. patient care) perspectives.

Medical informatics research has focused on studying how to construct an information system to make information sharing more efficient, especially on a larger scope). Our study shows a complex relationship between local knowledge and publicly available information sharing. It also shows a complex relationship between how medical work is socially distributed and medical information is socially constructed from a nursing perspective. Informal information (such as that transferred through oral means), information captured in records (permanent or temporary), and information on different media has different meanings to the participants due to differences in information's inherently political nature, physicality, mobility, and easy accessibility. When information is captured in an informal, temporal, local, and tangible means, it affords convenience and mobility (such as PS, AS and Kardex) and allows certain level of autonomy, respecting the nature of nursing work (such as with the SRS and audiotape). Furthermore, nursing care information can often be very subjective in its interpretation [4]: A nurse may make a note that says "possible sundowner" on a group-only

shared document noting an observation of a patient's behavior change after sunset. That would not be formally diagnosed by doctors yet might be important for understanding a patient in a potentially difficult situation.

Computerization of medical work can bring what was informal and impermanent into permanence and formality with the promise of accountability, safety, and facilitating information sharing in real-time on a larger scale. What we have learned from this study is that certain information, once becoming part of the permanent record and shared within a larger scope, could largely vanish. Its original written form was a systematic group practice and shared social arrangement, and this could also vanish. In this case, the automated common information space ironically hinders information sharing, which previously afforded contribution by everyone in the paper-based operation.

Indeed, nurses are very aware of the loss of rich nursing care information. They reported that they were "still struggling" how to make the Comments page in CPOE more fully used to share nursing care information. From this practical perspective, how to bring back that "personal stuff" about patients in nursing care in a more systematic way and via a collaboratively-oriented practice is a key concern.

This lesson raises a technical question of how to treat the local knowledge practice in the design of computerization of medical information. In addition to the politics of local knowledge embedded in these assembled information objects, the heterogeneous nature of local practices makes it very hard to computerize local working documents in a uniform format to meet the potentially different needs of each different nursing unit (e.g. internal medicine unit for adults vs. a pediatric unit). Indeed, local working documents are the informal representation of local practice. Computerization tends to formalize and uniform practice, which is necessary in certain situations (e.g. to enforce a standard order prescription practice for doctors); however, it should not ignore specific and unique nursing practices in different units.

One nurse from the unit has already taken the lead trying to develop a template for entering information into the CPOE system. At this time, we are not sure whether this effort will work, since the information entered into the CPOE is still part of the permanent record system and nurses' concerns may not be adequately addressed with *only* this template. The critical issue in this regard should be to acknowledge the *informal* nature of some information. For instance, the system design should perhaps give nurses' control regarding what they want to do with the information after a patient is discharged. The life cycle of nursing care information would then be determined by the nurses, as it was previously when the SRS was in place.

Organizationally, the visibility, convenience, and accountability of a group practice should be warranted for nursing information sharing. Prior to the CPOE, nurses all came to the conference room to note on their SRSs, and nurses counted on one another for information sharing. The conference room previously served as a common information space for this collective information production. After the CPOE, the common information space has been moved into CPOE with its Comments page; but sadly, the group practice became individualized. How to reverse this individualization and foster any intended group practice should be a concern from both the organizational and technological perspective.

Finally, this study also points out that while nurses need to get enough information before taking any action for patient care, the information which contributes to a better *knowing* of that patient may not be presented in an easy way. Therefore, how to provide nurses with an overview of a patient's medical history, including some narrative description about the patient, a fuller description of the current illness within the patient's larger medical and care contexts within a CPOE should be considered in any design activities. If a CPOE is designed in a way that nurses can get this knowledge with just a glance and in a way that is hard to ignore, as was done with the original SRS, nurses would gain a better familiarity for patients with no extra effort. We can safely assume this would be greatly appreciated by patients, because the people who provide care for them would know them much better.

7. CONCLUSION

Building on an earlier study in understanding how group documents were used to support information sharing in nursing [20], in this paper, we examined a detailed and representative case to show how the nurses' information assembling process changed, from before to after a CPOE system's adoption. Before the CPOE adoption, nurses used several collaboratively-created group working documents to assist in an information assembling process; after the CPOE adoption, they mainly used the CPOE itself for their information needs. We found while computerization facilitated medical data assembling process and improved order handling practice, it also resulted in some information gaps in understanding patients in their larger care context. We also showed how the computerization of medical information can turn local knowledge into more readily available information objects, but in the process, make that information more publicly available, the hampering the information sharing the computerization was intended to foster.

8. ACKNOWLEDGMENTS

We are grateful to all nurse participants of the study. This work was supported in part by the University of Michigan Rackham Barbour Scholarship, the National Science Foundation (#0325347), and Grant #UL1RR024986 received from the National Center for Research Resources (NCRR), a component of the National Institutes of Health (NIH) and NIH Roadmap for Medical Research.

9. REFERENCES

- [1] Ackerman, M. and Halverson, C. 2004. Organizational Memory as Objects, Processes, and Trajectories: An Examination of Organizational Memory in Use. *Journal of CSCW*. 13, 2(2004), 155-189.
- [2] Asaro, P.V. and Boxerman, S.B. 2008. Effects of computerized provider order entry and nursing documentation on workflow. *Acad Emerg Med*. 15, 10(2008), 908-915.
- [3] Bannon, L. and Bødker, S. 1997. Constructing common information spaces. *Proc. of ECSCW*, 81-96.
- [4] Bowker, G. and Star, L. 1999. *Sorting Things Out: Classification and Its Consequences*. MIT Press.
- [5] Cabitza, F., Sarini, M., Simone, C., and Telaro, M. 2005. When once is not enough: the role of redundancy in a hospital ward setting. *Proc. of GROUP*. ACM Press, 59-68.
- [6] Campbell, E.M., Sittig, D.F., Ash, J.S., Guappone, K.P., and Dykstra, R.H. 2006. Types of unintended consequences related to computerized provider order entry. *J Am Med Inform Assoc*. 13, 5(2006), 547-556.
- [7] Chen, Y. 2010. Documenting transitional information in EMR. *Proc. of CHI*. ACM Press, 1787-1796.
- [8] Glaser, B. and Strauss, A. 1967. *Discovery of Grounded Theory. Strategies for Qualitative Research*, Aldine Publishing.
- [9] Hardstone, G., Hartswood, M., Procter, R., Slack, R., Voss, A., and Rees, G. 2004. Supporting informality. *Proc. Of CSCW*. ACM Press, 142-151.
- [10] Koppel, R., Metlay, J. P., Cohen, A., Abaluck, B., Localio, A. R., and Kimmel, S. E. 2005. Role of Computerized Physician Order Entry Systems in Facilitating Medication Errors. *JAMA*. 293, 10 (2005), 1197-1203.
- [11] Miles, M. and Huberman, M. 1994. *Qualitative Data Analysis*. Sage Publications, Inc., 2nd edition.
- [12] Munkvold, G., Ellingsen, G., & Koksvik, H. 2006. Formalizing work: reallocating redundancy. *Proc. of CSCW*. ACM Press, 59-68.
- [13] Niazkhani, Z., Pirnejad, H., de Bont, A., and Aarts J. 2008. Evaluating inter-professional work support by a computerized physician order entry (CPOE) system. *Stud Health Technol Inform*. 136(2008), 321-326.
- [14] Niazkhani, Z., Pirnejad, H., Berg, M., and Aarts, J. 2009. The impact of computerized provider order entry (CPOE) systems on inpatient clinical workflow: A literature review. *J Am Med Inform Assoc*. 16, 4(2009), 539-549.
- [15] Pirnejad, H., Niazkhani Z, van der Sijs, H, Berg, M, and Bal R. 2009. Evaluation of the impact of a CPOE system on nurse-physician communication—a mixed method study. *Methods Inf Med*. 48, 4(2009), 350-360.
- [16] Tang, C. and S. Carpendale. 2007. An observational study on information flow during nurses' shift change. *Proc. Of CHI*. ACM Press, 219-228.
- [17] Tellioglu, H. and I. Wagner. 1997. Negotiating Boundaries. Configuration Management in Software Development Teams. *Journal of CSCW*. 6, 4(1997), 251-274.
- [18] Wagner, I. Women's voice: The case of nursing information systems. *AI & Society*, 7, 4 (1993), 295-310.
- [19] Zheng, K., Haftel, H.M., Hirschl, R.B., O'Reilly, M., and Hanauer, D.A. 2010. Quantifying the impact of health IT implementations on clinical workflow. *J Am Med Inform Assoc*. 17, 4 (2010), 454-461.
- [20] Zhou, X., Ackerman, M., and Zheng, K. 2009. I just don't know why it's gone: maintaining informal information use in inpatient care, *Proc. Of CHI2009*. ACM Press, 2061-2070.