The effects of EMR deployment on doctors' work practices: A qualitative study in the emergency department of a teaching hospital

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ABSTRACT

Objective: The goal of this study was to examine the effects of medical notes (MD) in an electronic medical records (EMR) system on doctors' work practices at an Emergency Department (ED).

Methods: We conducted a six-month qualitative study, including *in situ* field observations and semi-structured interviews, in an ED affiliated with a large teaching hospital during the time periods of before, after, and during the paper-to-electronic transition of the rollout of an EMR system. Data were analyzed using open coding method and various visual representations of workflow diagrams.

Results: The use of the EMR in the ED resulted in both direct and indirect effects on ED doctors' work practices. It directly influenced the ED doctors' documentation process: (i) increasing documentation time four to five fold, which in turn significantly increased the number of incomplete charts, (ii) obscuring the distinction between residents' charting inputs and those of attendings, shifting more documentation responsibilities to the residents, and (iii) leading to the use of paper notes as documentation aids to transfer information from the patient bedside to the charting room. EMR use also had indirect consequences: it increased the cognitive burden of doctors, since they had to remember multiple patients' data; it aggravated doctors' multi-tasking due to flexibility in the system use allowing more interruptions; and it caused ED doctors' work to become largely stationary in the charting room, which further contributed to reducing doctors' time with patients and their interaction with nurses.

Discussion: We suggest three guidelines for designing future EMR systems to be used in teaching hospitals. First, the design of documentation tools in EMR needs to take into account what we called "note-intensive tasks" to support the collaborative nature of medical work. Second, it should clearly define roles and responsibilities. Lastly, the system should provide a balance between flexibility and interruption to better manage the complex nature of medical work and to facilitate necessary interactions among ED staff and patients in the work environment.

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1. Introduction

Many healthcare organizations are undergoing a transition from paper records to "Electronic Medical Records" (EMR) systems [1]. Previous studies suggest the use of EMR has greatly affected the ways in which doctors document and manage patient information [2–8]. The influence of electronic systems on doctor work practices has drawn increasing interest from both the medical informatics and the human–computer interaction (HCI) communities. Literature in both these fields has studied the importance of human factors and organizational changes in the EMR implementation process; the EMR system influences not only people's behaviors at the individual level, but also the organization of work practices conducted in a healthcare institution. These studies have examined the influence of Information Technology (IT) on people's behaviors in a variety of work practices such as hospital inpatient units and outpatient clinics [9], and explored both beneficial and detrimental effects of computerized documentation on clinical and educational practices [10]. However, the majority of these HCI and Medical Informatics studies are either retrospective, conducted after the system had been implemented, or survey-based, focusing solely on one moment of an ongoing implementation process [10–12].

In this study, we intend to gain deeper understandings of how the design of EMR systems affects medical work practices by observing the rollout of the EMR *in situ* during the paper-to-electronic transition period. The EMR rollout at our field site is scheduled to occur in four phases over a three-year period. In this paper, we focused on the rollout of electronic MD notes, which was the first phase of the larger EMR study and only affected doctors' work practices. The importance of MD notes in healthcare is paramount. MD notes ensure patients' medical information is recorded accurately, efficiently, and quickly; and they provide written documentation for both medical research and legal purposes [2,13]. With the increasing adoption of EMR systems in the US, studying the effects of electronic MD notes has become a salient issue, since this may radically change every single aspect of doctors' work practices. Thus, efficient and effective documentation methods are always of interest to the medical informatics research community.

Although many studies have explored the consequences of EMR on clinical work practices and related design issues, such as usability or functionalities of EMR systems, in this study we intend to associate the work practices changes led by the EMR system with the actual design of the system and provide design guidelines for future EMR systems. This study aims to answer the following questions:

- How does the electronic documentation lead to the observed changes in ED doctors' work practices?
- What design guidelines could be used to alleviate these effects on ED doctors' work practices?

The timing of our study afforded us a unique opportunity to understand nuanced changes in ED staff behaviors and to obtain insight into the organizational impact of an EMR system during the paper-to-electronic transition of MD notes. Our study started three months before the system deployment, continued throughout one week of the deployment period, and ended three months after the deployment of the electronic MD notes. In our field study we found the deployment of the electronic MD notes had the following effects: (1) directly altering ED doctors' workflows and (2) indirectly affecting clinical collaboration and patient care (a consequence of the altered workflow). The direct effects of the system included longer charting times, workload changes, and workaround use developed by doctors. The indirect effects of system use included increased interruptions, increased multi-tasking, and decreased patient care time. These findings suggest system design should focus not only on medical practices, but on how the system will be used to conduct work practices. We suggest three design guidelines for electronic documentation systems: (1) design to support note-intensive tasks mainly affecting residents' work, (2) design to define different roles in collaborative work between residents and attendings, and (3) design to balance flexibility and interruption.

2. Related work

Previous studies indicate the use of Healthcare IT systems (HIT), such as Computerized Physicians Order Entry (CPOE) and Electronic Medical Records (EMR), can benefit medical practices in various ways, including providing easy access to and accurate documentation of patients' records [4–6], reducing potential medical errors [7], standardizing practice [2], improving the quality of patient care [2], and billing management [2,21]. However, these benefits are often coupled with unintended consequences in the actual work practices, such as increased documentation time [10,11], incompatibility with clinical workflow [10], more interruptions in medical work [22], and system-introduced errors in patients care [14,23]. Based on such findings, these prior studies indicate the importance of focusing on the possible consequences of documentation when studying HIT.

In particular, for the system being examined in the current paper, studies have shown electronic documentation can have diverse effects on clinical work processes. For example, Embi et al. [10] identify the fact that computerized documentation greatly enhances the accessibility and legibility of medical notes; however, electronic documentation changes the workflow, alters the structure of the MD notes, and even introduces errors into the documenting process. Other studies also examine changes in the work process. One suggests the way medical documents are "written, read and used" in electronic documentation systems has been largely overlooked [24]; another indicates the loss of important psychosocial information during the documentation process with deployment of the new CPOE system [25]; and the other presents a new framework for a document's life cycle based on when information is documented, who documents it, and how it is documented [26]. In addition, various design guidelines have been proposed to improve the usability of EMR systems, ranging from interface-level modifications such as supporting handwritten notes in electronic format [27], scanning and eliminating paper-based records for faster transition to full utilization of an

EMR [28], and improving alert functions [29], to broader-level changes, such as enhanced communication and education for both providers and consumers [30]. Nonetheless, how actual patient care and medical practices are affected by changes in the clinical documentation processes with the use of electronic systems remains unreported in these studies.

The use of new systems naturally leads to work practice changes; studies argue that human, social, and organizational factors play crucial roles in the deployment and use of Healthcare IT systems [31]. In a case study on the implementation of a management information system, Markus asserts that the system and its users should be studied together and considered as vital factors during the implementation process in order for the process of system adoption to be met with less resistance [16]. Similarly, Pratt et al. emphasize the importance of understanding of how individuals collaborate when designing and deploying medical information systems in computer supported cooperative work (CSCW) environments [17,18]. Other studies emphasize system implementation and its relationship to organizational change. For example, technologies were found to alter organizational structures in two case studies of the implementation of CT scanners in radiology departments [19]. In these case studies, the newly implemented CT scanners changed the institutionalized roles and the patterns of interaction among the radiologists and the radiology technicians in the departments. Technology deployments, such as the implementation of a patient care information system, are viewed as a process of mutual transformation between the organization and the technology rather than merely as a matter of bringing an automated tool into a working environment [20]. The use of technology is deeply interrelated with actions at the individual level, but also with interactions among individuals at the collaborative level and with social and organizational structures [32]. However, although these organizational studies and design papers discuss various social consequences resulting from the use of healthcare IT systems, they rarely associate these consequences with the original system design and provide design guidelines to alleviate these effects.

In this paper, although we focus on human factors and organizational changes emerging during the paper-to-electronic documentation transitions as seen in previous studies, we attempt to provide new insights into EMR studies by associating the system's effect on doctors' work practices with the EMR design itself and providing design guidelines based on our field observation.

3.   Methodology

3.1.   Setting

The primary objective of ED care is to stabilize patients' medical problems promptly and move them out of the ED, either discharging them or admitting them to an inpatient unit. ED doctors treat a wide variety of illnesses which range from mild to life-threatening. Depending on the acuity of illness, patients in the ED may reside in three different units: ED1, ED2, or ED3, respectively ranging from the most to least severe. Each ED
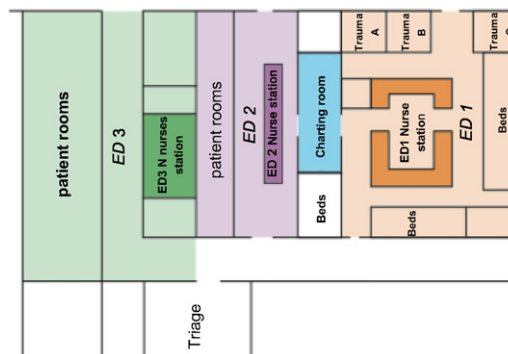

Fig. 1 – A map of the main ED area.

unit has a nursing station and a shelf where paper medical records were kept before the rollout of EMR.

In addition to the three ED units, there is a separate charting room located at the center of the ED. The charting room is for ED doctors, including both attending physicians (herein attendings) and resident physicians (herein residents), to document their MD notes and discuss various medical cases. The charting room is directly connected to ED1 and ED2, allowing doctors to check up on the more severely ill patients with more convenience and at more frequent intervals. ED3 is relatively further away from the charting room since the patients in ED3 are relatively stable and are less likely to have emergencies (Fig. 1).

To treat patients, ED doctors frequently interact with ED nurses, technicians, and doctors from other departments. When they visit patients' bedsides, doctors usually stop by the nursing stations to give or obtain verbal updates about the patients they manage. ED doctors have direct interaction with patients only during the initial assessment, when performing major treatments, when giving medical diagnoses and test results, and when discharging patients. Technicians and doctors from other departments often come to the charting room to report or discuss lab, radiology, EKG results, or patient admitting decisions with ED doctors. Other than a few trauma patient rooms, the majority of patient rooms in the ED had no bedside computers during the time this study was conducted – although it should be noted ED doctors did not use bedside computers for documentation even after these were installed following the system rollout. Instead of analyzing the reasons for the lack of bedside documentation behaviors, however, our focus in this paper is on the initial system deployment and how the design of system features leads to various direct and indirect consequences in ED work practices.

3.2.   Data collection

We studied the pre-, during, and post-EMR deployment periods using qualitative field study methods. Specifically, the timeline of our study spanned both the pre- and post-deployment phases, as well the transition phase from paper to electronic systems. In total, we conducted about 106 h of field observations and 8 semi-structured interviews over a period of 6 months (see Table 1 for details). Qualitative methods are commonly used in the Medical Informatics field [14,17,24,33].

Table 1 – Data collection including method, participants, and time spent (note: a few interviewees did not participate in our observation session, *T: The day of transition from paper to EMR-based practice).

Role	Data collection method	Number of participants	Data collection time (in h)
Attending physicians	Observation	9	40.5 (Pre-: 16, *T: 5.5, Post-: 19)
	Interviews	3	2
Residents	Observation	12	60 (Pre-: 22, *T: 6, Post-: 32)
	Interviews	5	3.3
Total		23	105.8 h

These methods provide an in-depth understanding of the influence of technology use on medical practice by drawing attention to the interaction of technology with people, artifacts, and organizations *in situ*, and afforded us opportunities to gain a more nuanced and detailed understanding of the paper-to-electronic transition process. We were able to recognize how doctors interact and use different documentation tools based on role; develop a detailed description of system users, their interactions, and the ED environment; and identify conflicts or breakdowns currently or potentially affecting ED workflow and workload.

Researchers began observations by following the clinical documentation process in key locations in the ED: the patient waiting room, front desk, triage, nursing stations, charting room, patient rooms, and other public areas in the ED. During the observation, two researchers stayed in the same locations to observe ED activities and how different artifacts, such as paper charts, and the electronic system, were used to support these activities. Researchers also followed key personnel and artifacts such as patients' paper charts, in order to comprehend the general ED workflow from various perspectives.

Researchers also shadowed 21 doctors to gain a more contextual understanding of their behavior changes during the EMR deployment period. Data collected from other medical personnel are not described in this current article since they are not directly related to the deployment of electronic MD notes in the EMR. During the shadowing sessions, the two researchers followed each individual physician, with each session lasting approximately 4–5 h. During the shadowing sessions, researchers remained unobtrusively behind study participants and recorded notes related to work tasks, technology use, and interactions with others. When possible, brief questions were used to let doctors elaborate on their actions and confirm researchers' understandings if the situation allowed. The hand-written field notes were transcribed into concrete notes soon after each session of the observation was finished.

In addition, 8 semi-structured interviews were conducted in post-deployment to collect ED doctors' perceptions about EMR rollout. Among the 8 interviewees, 3 were attendings and 5 were residents. The interviews centered on the doctors' understanding of their work practices with the new EMR system, their opinions of electronic documentation, and their perception of the effects of the system on their work practices. Specifically, researchers asked doctors when, where, and how they documented patient charts; how they perceived their work practices had changed; and how they had adapted their previous documentation behaviors to the new system. The

interviews took 40 min on average and were audio-recorded and transcribed for data analysis.

3.3. Data analysis

After completing the observations and the interviews, we reviewed the data collected in the study in order to understand ED doctors' documentation behaviors during EMR implementation. We deployed affinity diagramming [34] to identify themes regarding the use of the EMR system across a variety of aspects in ED work practices. We analyzed the data by sorting through them, according to various roles the ED staff undertakes, the physical locations of ED work, and the general patient treatment processes. We also created various workflow models [34] to reveal how physical artifacts move through the patient care process, and how patient care information flows between doctors, nurses, and other ED staff members during the documentation and the communication processes. Through these activities, we were able to recognize where and how the EMR system was used and why individuals have different perceptions of it. The data were then analyzed using an open coding technique [34] to identify patterns of behavioral changes regarding the documentation work before and after the EMR deployment. These data analysis methods allowed us to present a systematic and in-depth view of the rollout process.

4. Overview of EMR deployment

The EMR at our field site was deployed in multiple stages. What we report in this paper is the rollout of the electronic MD notes function; during this stage, only ED doctors' documentation work was transitioned into the electronic system. The order system, the electronic triage note, and the nursing documentation system were scheduled to be implemented later on. In this section, we look at the ED doctors' documentation work as it changes from paper to EMR-based electronic note charting. An MD note, also referred to as a progress note, is one of the most important documents in patients' medical records and in doctors' clinical workflow. Doctors usually document their notes after patient interviews, after lab, radiology, or other test results, and upon diagnosis.

4.1. Documentation prior to EMR

Before the use of EMR, paper charts were the primary documentation tools in the ED. Paper charts contain a note entry

Fig. 2 – ED doctors' paper charts (left-hand section for residents, right-hand section for attendings).

for doctors to record patients' basic information such as medical history, physical exam results, diagnoses, and patient care plans. They are structured with two separate sections: the left-hand section is for residents and the right-hand section is for attendings (Fig. 2).

On a patient's arrival, a triage nurse created a paper chart to assess the patient and decide which unit the patient would be placed in the ED. After the patient was assigned to a bed, the chart moved to a charting room by the triage nurse. A resident usually picked up the chart first and went out for consultation with the patient. At the patient's bedside, a resident recorded a detailed medical history, symptoms, and observations from physical examination. After bedside assessment, he took the chart back to the charting room where he finished charting before presenting the case to the attending and giving him the chart. As the resident presented each case, the attending asked questions relevant to medical decisions. Based on the resident's presentation, the attending then started his part of the paper chart (the right-hand section). After the attending obtained enough information about the patient and finished recording it on the chart, he traveled to the ED unit to check on the patient and to complete his section of the paper chart, usually at the nursing station. Then, the paper chart stayed in the records shelf located in each ED unit until the patient was discharged or admitted. When documenting on paper charts, attendings held more responsibility than residents in documenting diagnoses, medical decision-making, and treatment plans. They were also in charge of finalizing the patients' charts, whereas residents primarily wrote up the initial assessment information and a brief medical history (Fig. 3). In this paper-based operation, both residents and attendings were clearly aware of their respective documentation tasks and responsibilities.

During the course of patient care, whenever ED doctors documented charts or put in orders, they had to go to the nursing stations to pick up the paper charts. As a result, the doctors naturally interacted with nurses and spoke about the progress of their patients whenever the charts were picked up. Upon each patient's discharge, the paper chart was delivered to the administrative staff to make sure the documentation was complete; they sent it to storage for the patient's permanent medical record. If a chart was incomplete, administrative

staff or a charge nurse sent it back to the attending-in-charge to complete.

4.2. Documentation practice after EMR implementation

After the EMR rollout, electronic MD notes replaced the previously used paper charts in the ED. The system had a pre-structured note entry for doctors to put down a patient's medical information. The new electronic MD notes were more comprehensive and required far more details than the previous paper charts, prompting users to enter not only medical history, physical exam results, and patient care plans, but also the results and interpretation of laboratory tests, radiology imaging, diagnoses, and handoff notes. Also, every ED staff had access to MD notes from any terminal in the ED.

Unlike the paper chart system, electronic MD notes did not define separate spaces for residents' and attendings' notes. With the EMR, residents and attendings both documented on the same section. After seeing a patient at bedside, a resident came back to the charting room and filled out the notes, and then presented them to an attending. The attending read the information already documented in the electronic MD notes and added information on the same page when necessary. After speaking with the resident, the attending checked on the patient and returned to the charting room to update the electronic MD note, adding missing information when needed. When the attending finalized the documentation, all electronic MD notes were completed and saved permanently in the EMR system. Since the EMR system containing all the MD notes was web-based, it allowed doctors to access and manage incomplete charts even after their shifts (Fig. 3).

5. Findings from fieldwork

Our study indicates the electronic MD notes system shifted documentation workload and caused workflow changes among ED doctors in our field site. In turn, these changes influenced the way ED doctors interacted with nurses and patients.

5.1. Direct consequences on documentation process changes

The use of electronic documentation in the EMR system directly affected the division of labor between attendings and residents. Despite a few studies assessing different roles among doctors [10,35,36], most previous literature did not differentiate between ED doctors [10,12,14,15]. However, our study notes that the use of EMR affects residents' and attendings' work in very different ways; as a consequence, they take on different roles and responsibilities during the patient documentation process.

5.1.1. Workload reshuffle
In a teaching hospital, a patient's record is collaboratively documented by a resident and an attending. With paper charting, residents and attendings had clearly defined responsibilities, since they each had their own section in the MD notes. However, after the introduction of the EMR, residents had to take on
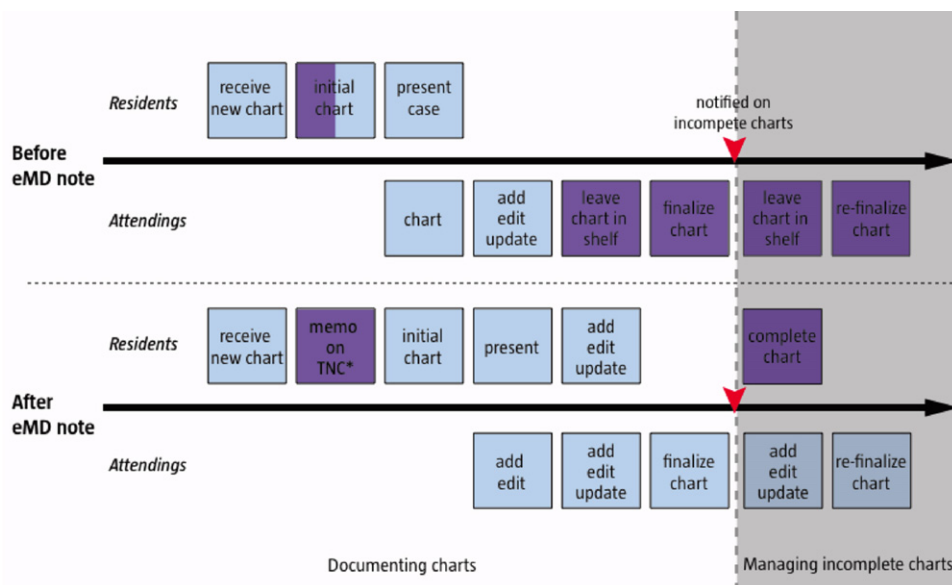
Fig. 3 – Simplified documentation process in the comparison between before and after EMR deployment. (TNC[*]: Triage note copy, Blue: charting room, Purple: outside of charting room). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

more documentation-related tasks than previously; the time residents spent on charting work exceeded the time attendings used to devote to the same tasks (Fig. 3). In an interview, one resident spoke about how long the charting process took him:

> "[Resident Steve[2]] From the patient care perspective, the EMR system has lots of advantages, but from residents' perspective, it just slows us down… It takes probably 3 to 4 times longer than paper charts … and the other thing is it takes so much time that I'm not even able to chart. A lot of times actually I just have to save 10 notes to the end of my shift and actually stay extra hour to chart."

Another resident emphasized how much of documentation work residents are engaging.

> "[Resident Ted] We do most of work for them (attendings) and they just add something."

As these quotes indicated, the use of the electronic MD notes led to an increased workload for residents due to the longer charting times and the shifted responsibility from the attendings. Interestingly, most of the attendings had positive opinions about the new system and a few even found charting to be faster than before.

> "[Attending Karen] In my perspective, it's million percent better… It's so much faster and more reliable."

The two distinct attitudes towards the EMR, as shown in the interview excerpts above, reflect the shift caused by the system design in the internal division of labor between residents and attendings.

Since residents see the patient before attendings, they tend to start and perform all the main documentation of the patient charts, including diagnosis and care plan notes previously done by the attendings, whereas the attendings added, updated, and finalized the charts after the majority of the bodywork was done. In our observation, in paper-based practice, we always saw two or three residents waiting to present their finished charts to an available attending. However, the roles were reversed with electronic MD notes. The residents were the ones typing notes at computers: attendings often spent time waiting for residents to finish their charting work and checking in to see if the residents were ready to present patient cases. This shift in waiting time from the residents to the attendings also reflects the way the electronic MD notes' design changed the ED doctors' documentation workflow. The lack of clearly defined work responsibilities and roles in electronic documentation forces residents to take on additional documentation tasks previously completed by attendings, which eventually led to changes in residents' and attendings' workflows.

5.1.2. Altered management process for incomplete charts

Another task previously handled solely by attendings – managing incomplete charts – is now collaboratively managed by both attendings and residents in the EMR system. In other words, residents are taking on a workload not previously performed by them, partially due to the use of the new system. As described earlier, in the paper-based work practice, a nurse put the charts on the shelf in the ED unit, and when a patient was discharged or admitted, a secretary or charge nurse sorted those documents for the purposes of filing medical records or billing. If a chart were found to be incomplete, for example,

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[2] All names used in this paper are pseudonyms to ensure anonymity of participants.
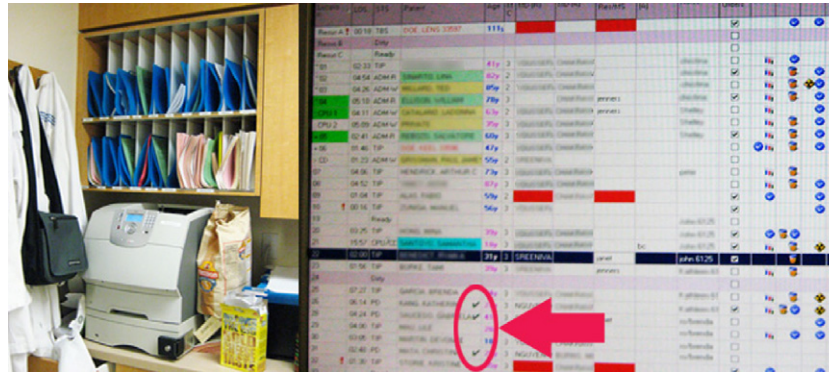
Fig. 4 – Incomplete paper charts piled up on the shelf in the charting room previously (left), and a screen of the current EMR with various flags and icons (right: checkmarks next to patient names for incomplete charts).

missing information or signatures, the charge nurse would return it to the attending who had been in charge of the patient. Depending on the daily workload, each attending normally might have a pile of incomplete charts to finish at the end of his shift.

The EMR makes the management of incomplete charts much easier and quicker. Instead of having a secretary or a charge nurse to check for incomplete charts, the system automatically identifies the incomplete charts and labels them with a "checkmark" (Fig. 4). Unlike paper-based practice, where designated bookshelves receive all the incomplete charts for attendings to manage, EMR practice provides easy access to both attendings and residents but does not define the roles or responsibility in their documentation work. The lack of clearly defined roles in the collaborative documentation process leads attendings to residents asking them to complete the charting when they discover incomplete charts. Residents are now expected to work on incomplete charts even after their work hours. Thus, as a result of the electronic documentation, residents are involved in the process of managing incomplete notes – a task previously performed solely by attendings. During our study, we saw residents receive many emails regarding the incomplete charts on every shift. Many felt their workload had increased since taking on these new tasks, as one resident complained in our interview.

> "[Resident Paula] I get emails sometimes from attendings because of incomplete charts...I actually got a lot (of emails). I know some of other residents get them as well."

Therefore, EMR use shifted the responsibility for managing incomplete charts from attendings to residents. The undefined roles and accessibility of electronic MD notes made it possible for the attendings to pass on the incomplete charts to the residents and transfer their part of workload to the residents.
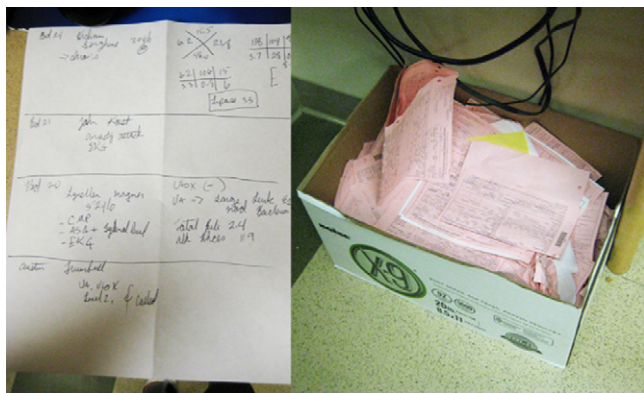
5.1.3. The use of workarounds

The deployment of the electronic MD notes also changed the location of documentation and led to use of paper notes as a workaround. Previously, with paper records, residents were able to finish charting within just 2 or 3 min, whereas documentation may take 8–10 min with the electronic notes. Since

the electronic MD notes required more comprehensive patient notes and took longer to complete, ED doctors preferred to perform their charting work in the charting room. To do so, they had to gather and memorize information at patients' bedsides first, then type it out in the charting room later. When doctors – especially residents who collect information initially – had to take care of multiple unfinished records at the same time, memorizing and transferring all the information often became a challenge. To deal with this situation, ED doctors developed a habit of using personal hand-written notes as memory aids to carry bedside information back to the charting room for later documentation, jotting down information during patient interviews. Soon after the EMR rollout, residents started writing down information they needed to know on the "triage note copies" after seeing patients and carrying these notes until their shift ended or the patient was discharged.

A triage note contains patients' basic information (*e.g.*, patient name, chief complaints, and vital signs) and is the only paper document containing patient information still received by ED doctors after the EMR rollout.[3] Residents used these triage pages during bedside consultations to record chief complaints and/or medical history. They then carried the personal notes to the charting room and typed the official MD notes on the computer based on these personal notes. The personal notes were also used to remember the medical procedures residents had performed and to keep track of multiple patients. Usually residents ended up carrying 7–8 triage notes at a time, each page for one patient. Similarly, attendings also developed their own way of carrying personal notes around. Though they did not receive paper notes, attendings used a blank paper from the printer bin or a ¼ folded paper for keeping memos (Fig. 5). They usually wrote down important patient care information, such as the patient's name, bed number, chief complaints, and the name of the caretaker. The use of these notes was by no means an individual endeavor; it was a common behavior shared by almost every ED doctor we shadowed.

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[3] The paper triage note system switched to electronic triage in the later stages of EMR implementation.

Fig. 5 – An attending's personal note (left) and used triage note copies after use (right).

In addition to the use of memory aids, this use of paper notes as a workaround reflects an incompatibility between the electronic MD notes design and ED doctors' documentation workflow. The main goal of ED doctors is to make quick medical decisions and record them concisely for multiple patients who may reside in different ED units. ED doctors have to move around constantly to obtain all the necessary information for them to make these decisions. Since each patient has a different history and a different patient care process, it is very difficult for doctors to commit all of the details to memory. The use of the computer system does not support the multiple patient care process and the mobile nature of ED work – hence the use of paper notes as an information repository.

5.2.   Indirect consequences on clinical collaboration and patient care

In addition to the direct effects introduced above, the use of the EMR also resulted in much broader consequences, indirectly influencing the ways clinical work and patient care are conducted in the ED. These indirect effects are the consequences of the direct effects – residents' increased documentation workload and documentation location change, as described earlier.

ED work requires doctors to engage in multiple tasks at the same time. However, residents' increased workload and the time they were required to spend on documentation-related work increased their need to multi-task. In turn, this reduced the amount of attention and time they devoted to other collaborative tasks with ED staff. The following observation shows how electronic charting caused a delay and increased multi-tasking in a resident's work, and suggests how it might further influence their collaboration with nurses – another critical patient care role in the ED:

Shelley [resident] was in the middle of charting in the charting room and a nurse who worked in ED2 came in, asking if the prescription for a patient at bed #26 was ready. She realized the prescription was left on the printer. Even though the order was already prescribed and printed out, Shelly

had forgotten to hand the prescription[4] to the nurse since the electronic charting task she was working on was taking too long to finish. While signing this prescription, Shelley complained that if she didn't chart right after seeing a patient, it would have taken much longer to recall the patient case and the amount of time spent on the MD note charting might have taken even longer.

As shown in this observation, the increased time and attention residents needed to devote to the charting caused them to shortchange other tasks, in turn creating a regular need to interrupt charting to do catch-up work on these overlooked tasks, such as handing a prescription to a nurse. In addition, the practice of keeping several triage notes (personal notes) aggravated this behavior; it enabled residents to postpone their charting work while carrying out other tasks. As a result, this work pattern led to delays and increased multi-tasking in their work. The increased multi-tasking occupied residents' attention and influenced their collaboration with other ED staff, just as the resident, Shelley, forgot to bring the prescription to the nurse, which affected the nurse's own continuation with her other tasks.

Additionally, the flexibility of electronic charting in the EMR, such as the ability to pause, resume, and save, is another factor leading to increased multi-tasking in residents' documentation process. Clearly, the use of the paper charts limited access to patient records since there was only a single copy available on the ED floor. Because of this limitation, doctors always tried to finish their documentation and make paper charts available for use as quickly as they could. In contrast, electronic charting offered much more flexibility in the charting process. Residents were able to document in the chart at any time and there was no need to finish the chart all at once, or as quickly as before. They were able to push unfinished charts aside to work on more urgent tasks and then resume the documentation later on. Having several unfinished patient charts at hand forced doctors to carry all the undocumented information with them and potentially required more effort for them to recall what they needed to document for each patient before the interruptions occurred. This could eventually affect other nurses or attendings whose work was reliant on accessing timely information documented in the EMR system.

The documentation location change also reduced the time residents spent on direct patient care, since electronic charting caused ED doctors to spend more of their time in the charting room. As the doctors' work became more stationary, less time was spent in the nursing stations and the patients' rooms. This was seen mostly among the residents since they were heavily involved in the use of the EMR. In our observations, residents often stayed in the charting room, busy typing notes for hours, without stepping out to the ED units where the patients were. Consider the following scenario:

James [resident 1], was working in front of his computer in the charting room when a nurse from ED1 came in with an EKG printout of a trauma patient who recently arrived at

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4   During the time when our study was conducted, medical orders were still prescribed using papers.

the ED. James took a look at the EKG printout, then resumed his charting job. A couple of minutes later, another nurse from the ED2 went over to inform James of one of his patients' allergy information and asked which medication she should give to the patient. James quickly wrote down the order for the patient and continued note typing. Later, James complained to Ted [resident 2], who also stayed in the charting room busy writing notes, that he had only seen two patients so far due to the longer charting time.

This observation illustrates the fact that residents became more durably stationed in the charting room after the deployment of the electronic MD notes (Fig. 6), less likely to check patient situations when they were busy documenting in the systems. Nurses and technicians had to come to the charting room to ask questions of the residents. In the case described above, James' decreased time outside the charting room meant fewer opportunities to see patients, and the amount of time he spent talking to other ED staff was decreased. His patients' care information was not directly observed, but was instead reported by the nurses. After the rollout of EMR, we frequently saw residents express concern about not being able to interact with patients as much as they had previously.

In the work practice before the electronic MD notes, when not discussing patient cases with attendings or preparing discharge materials, residents primarily stayed in the ED units to talk to nurses or check on their patients' condition at the bedside. During our interview, one resident compared how he spent his time before and after the EMR deployment:

[Resident Simon]…"Well that's the thing. You can see less patients since you are spending more time on computers, whereas before you could do a lot of documentation at the bedside. You are actually standing at the bedside to fill out your charts…So I definitely find myself spending a lot more time at the computers and less time talking to patients."

This quote resonates with our observations about a decrease in direct patient contact after the EMR implementation. Time spent checking patients and talking at the bedside is considered critical for doctors to maintain awareness of their patients' situations and to attend to the subtle psycho-social aspect of patient experiences during emergency visits [37–39]. A reduction in direct patient contact may detract from doctors' ability to make such observations, which are crucial to monitoring patients' progress.

6.   Discussion

The findings of the study suggest the deployment of electronic MD notes has both direct and indirect consequences on ED doctors' work practices – direct effects caused by the actual use of the system and indirect effects following as consequences. The system directly affects the doctors' work processes by reshuffling workloads, by changing workflows, and by leading to the development of new workarounds. As an indirect result of the more stationary nature of their work with the EMR, the doctors may have decreased face-to-face interactions with nurses and patients located in the ED units. As

is evident in our study, the influence of the electronic MD note correlates with the way the system was designed to support patient documentation in the ED. Unlike many previous EMR studies, ours looked at how documentation tasks were collaboratively managed by attendings and residents in the ED, and how ED doctors worked in a separate charting room instead of sharing work stations with the nurses after the EMR deployment. Overlooking these unique practices led to the above unintended consequences. In this section, we discuss the implications drawn from the study and provide guidelines associating system design with these organizational consequences.

6.1.   Designing for note-intensive tasks

Different from the previous study which found electronic documentation systems did not have different consequences on residents and attendings [10], we found the tasks in residents and attending' practices to be radically different in the ED, where residents often engage in what we called "note-intensive tasks", and attendings' work is mainly focused in "clinical-decision tasks" (see Table 2). As suggested in the findings section, electronic documentation primarily affected tasks involved directly in the process of entering notes into the computer system (residents' work), instead of tasks related to medical decision-making (attendings' role). EMR system design was often focused on enabling quick and better clinical decision making, and did not always pay sufficient attention to how notes were actually entered by doctors. This explains why the residents complained about the EMR, and why it was applauded by the attendings.

Note-intensive tasks are typically performed by ED residents. These tasks include conducting and documenting physical exams, medical treatments, entering orders, admitting and discharging patients. All of these tasks require detailed documentation. They are often time-consuming and rely heavily on the use of the EMR system. Clinical-decision tasks, however, require less computer interaction, but more clinical expertise. These clinical-decision tasks are conducted by ED attendings and can be completed with minimal time and effort with EMR system use (Table 2).

Our observations in this study suggest that the EMR system provides sufficient support for clinical-decision tasks. These functionalities, such as the easily accessible, simple displays of patient medical information, and the convenient notifications, are mainly used in the clinical decision-making process and are greatly appreciated by the attendings. On the other hand, compared to the paper records, the note-intensive tasks became more specific, more complicated, and more time-consuming to perform in the EMR system. Compared with the previous use of a single sheet of paper, the electronic MD note was much longer and more comprehensive due to its interface design and required contents. Having more sections to fill out in the electronic documentation, residents now spend a longer time charting than they did with the paper records. As opposed to the quick, free hand-writing on the paper charts, residents need to switch back and forth from clicking through many checkboxes and radio buttons, to typing in textboxes. For example, for the diagnosis part, residents now have to type out a diagnosis in very specific

Fig. 6 – Paper records storage in the nursing station (left) and doctors' charting with electronic MD notes after the EMR (right).

Table 2 – A list of tasks in ED doctors' work in our study.		
Task type	Note-intensive tasks	Clinical-decision tasks
Executer	Residents	Attendings
Tasks	• Physical exams • Patient consultations • Patient previous medical history • Medical treatments • Initial documentations • Order submissions • Checking and receiving updates and results • Admitting and discharging patient	• Diagnosis-related decision making • Treatment plan • Approving or finalizing documents • Interpreting results • Making decisions on admitting, transferring patient, or discharging patient • Evaluating or educating residents and med students

and detailed format in the MD notes, since the electronic MD note includes a big textbox field, whereas they used to write down only a few lines on the paper charts. Though the more concrete notes are considered beneficial for documenting detailed patient encounters and patient information, it also leads to a more time-consuming charting process in the ED and less time for other patient care activities during the ED doctors' fixed work hours. Furthermore, it could unexpectedly affect their educational development. Since residents spend a big amount of time on inserting information on computer, they may not have enough time to interpret the data and pursue their intellectual development as physician trainees. These findings are in line with the previous findings in Embi et al. and Thielke et al.'s works. They reported heavy use of features such as copy, paste, and automated data insertion and asserted residents were using all available means to expedite the many tasks assigned to them [10,35]. Embi's study further reported that Computerized Physician Documentation (CPD) led to a diminished expression of thoughtful assessment in the clinical records since in addition to already prolonged information-entry time, residents are not willing to spend the extra time needed to express their thought processes as fully as they did when handwriting their notes [10].

Notably, while clinical-decision tasks would seem to be more important from the patient-care perspective, they can only be performed after the execution of note-intensive tasks. For example, when the EMR system provides "check mark" notifications for incomplete charts and various "icons" for lab or X-ray results, they help attendings make efficient medical decisions and expedite the decision-making process by automatically presenting real-time patients' information. However, these features do not support faster note-taking or order prescriptions for residents. Instead, the process of entering notes and orders which must completed before certain actions can be taken is more cumbersome and time-consuming. Similarly, the more easily accessible MD notes enhance attendings' oversight and awareness of high-level patient care delivery since they can read residents' documentation from multiple locations at any time [10], but the actual documentation is significantly longer for residents to complete. Due to the lack of sufficient design consideration for these note-intensive tasks, most documentation tasks suffer from a prolonged charting time and a more complicated workflow. From the medical perspective, having more concrete, detailed information is good, but in ED work practice, it slows down the workflow and makes residents stationary in front their computers. To address this, we suggest the design of an electronic documentation system which goes beyond solely considering the benefits of supporting clinical-decision tasks, and more importantly, supports the note-intensive tasks for which residents are responsible. For instance, a system might provide two different modes for using MD notes, one for entering information and another for viewing/editing. When inputting information, the questions could be grouped based on types of questions so that a user would do all the typing first, followed by clicking radio buttons, instead of switching back and forth in between different interface formats. Later, when viewing or editing after initial documenting, the information entered

would be presented in the normal order. Also, the information from the triage note might be automatically transferred to MD notes so that residents would not need to re-type the same information or refer to the triage note while charting. This could help streamline ED documentation work gradually.

6.2. Defining roles explicitly in the collaborative documentation process

MD notes are collaboratively written by ED residents and attendings in teaching hospitals. However, the design of the EMR falls short of supporting this collaborative practice. One unique goal of the teaching hospital is to provide training for residents and medical students. Therefore, at our field site, residents prepare, document, and present patient cases to attendings, and attendings then make decisions and document accordingly. Whereas attendings solely document patients' charts in other non-teaching hospitals, the residents and the attendings work collaboratively; beginning with the documentation process, residents and attendings chart, discuss, and share MD notes. Thus, the chart-writing process itself is a collaborative endeavor and requires a system design which acknowledges this and supports it.

Moreover, compared to the distinctly defined roles, which existed previously in the paper records era, the newly deployed electronic MD notes system does not distinguish between the charting roles of the residents and those of the attendings, instead providing a single documentation area. Having undefined charting roles during the collaborative documentation work process led to the workload reshuffle among the residents and the attendings. It also led to the residents taking on more responsibilities in the charting process, depending on their position in the hierarchical structure among doctors. Based on the traditional hierarchy where the attendings' role was to teach and supervise the work of the residents, it was naturally expected for the residents to get more of the documenting work responsibilities when the new electronic charting was introduced. On the contrary, attendings, who held a position of higher authority in the hospital, were expected to become more involved with planning or medical decision-making work. The implementation of electronic MD notes made this hierarchical structure among doctors even more pronounced and led to these unintended consequences for the residents' work. Our findings may be peculiar to teaching hospitals; nevertheless, as medical practice is collaborative in nature, the lack of attention to the different roles people play, such as attendings and residents in our case, in the collaboration process will lead to various direct and indirect consequences, as we identified in the study. The work redistribution introduced by the undefined roles in collaborative work practices when using an EMR system was also seen in other collaborative work, such as secretarial work. After the computerization of progress notes (physician notes), Vikkelsø argued, the division of collaborative documentation labor between physicians and secretaries was reshuffled. The computerized notes led to the physicians performing a new role; they wrote their notes directly into the system, instead of dictating to secretaries and making secretaries document [40].

The issue of undefined roles in the EMR system design is apparent not only in the documentation process itself, but also in the collaborative communication required after initial documentation. The lack of role-defining features in electronic MD notes may disrupt the communication between different medical staff members involved in patient care. ED doctors' documentation work is not only used by the ED doctors, but also by other medical staff. In particular, when a patient is admitted to an in-patient unit, nurses and doctors from a different department often make use of ED doctors' notes to access information related to patient's medical history, diagnosis or treatment plans. However, since the MD notes design does not explicitly specify which part of the MD notes is documented by whom, it is challenging for the ED nurses or non-ED doctors to find the appropriate person to contact for any inquiry on this information. It becomes even harder when there have been a few handoffs between doctors during the documentation process, even if they keep a record of handoff notes. This shows a need for a system design which gives due consideration to collaboration between residents and attendings in the documentation process. In order to reduce or eliminate these unintended consequences, we suggest defining rules or guidelines for how to assign roles for documentation work in the EMR. Such guidelines would aid doctors in defining responsibilities, dividing workload, managing workload, communicating with other medical staff, and achieving better systems adoption.

6.3. Balancing flexibility and interruptions in documentation work

As shown in our findings, ED doctors can start, pause, and resume a documentation task at any given time. Hence, doctors were able to edit and update information on the MD notes during patient's stay or even after they were discharged from the ED. This flexibility afforded by the EMR system may lead to more interruptions during documentation. Previously, paper charts required ED doctors to complete documentation promptly so it could be used by other medical staff and combined with other paperwork upon patients' discharge. For these reasons, the paper charts had to be documented in a timely manner and placed on the shelves in the nursing stations for others to use. On the other hand, with the EMR, ED doctors are always able to easily retrieve and start where they left off charting. This lack of time pressure in charting may appear to be beneficial only for busy ED doctors, particularly the residents who perform most of documentation work. However, due to this unrestrained charting time, doctors tend to give a lower priority to documentation tasks and work on the MD notes last. Indeed, they often work on charting at the end of their shifts, after patients are already discharged.

This flexibility in charting allows ED doctors to tolerate many interruptions and finish their charts later, resulting in increased multi-tasking and simultaneous management of more unfinished patient charts. Additionally, collaboration with other medical staff whose work relies on the information

from the MD notes become challenging. Although system flexibility allows doctors to have more control in their charting, too much flexibility can, in fact, slow doctors down and impede the overall patient care process. Moreover, these changes in the doctors' work practice can certainly lead to negative outcomes, such as most of the doctors' work being dominated by interruptions or their cognitive load being increased by constant thoughts or worries about tasks left undone.

Therefore, in designing the electronic documentation, thorough consideration should be given to the goal of maintaining a balance between flexibility and interruptions in work practices. If the system is too flexible, a doctor can be interrupted to an unacceptable degree, at which point the doctor cannot complete any of his work. On the other hand, if the system is too inflexible, it will not be able to reflect the nature of patient care in the ED, which is thoroughly characterized by urgency and unexpected interruptions in patient care. To achieve the appropriate balance between flexibility and interruptions, we suggest the EMR design limit the amount of multi-tasking doctors can engage in and enforce a certain timeline for doctors to complete tasks. Leaving too many incomplete charts at hand and having too many patient cases open at the same time should neither be encouraged nor avoided by the EMR system. Rather, to balance flexibility in the documenting process and the need for collaborative work, we suggest the electronic documentation system be designed to require doctors to complete charting within a certain number of hours after they see patients, instead of waiting until the end of their shifts. This limited flexibility would be beneficial to the individual's work as well as the collaborative work process, by enabling others who are reliant on certain medical information in a chart to quickly view and share information, instead of being forced to wait and/or being unable to check a patient's information until the chart is completed much later on.

7.   Conclusion

The electronic MD note system is a part of the larger EMR system deployed at our field site. Our field study took place when the documentation of the MD note was transitioning from paper charts to electronic MD notes. It was hoped that transferring the clinical practice from a paper-based system to an electronic system could greatly improve the legibility, readability, and searchability of medical records stored in the EMR system. These expected benefits emerged after using the electronic MD note system; however, other unintended consequences also influenced ED practice. Observation revealed the direct and indirect consequences of the deployment of the electronic MD note; these were (i) increased workload and responsibility for residents, including longer charting times and the management of incomplete charts; (ii) new workaround development such as use of personal notes by doctors; (iii) documentation location change due to the stationary charting, and (iv) indirect clinical collaboration and patient care. We found these direct and indirect consequences to be correlated with the design of the EMR system.

As our findings show, regardless of the benefits of EMR use, the design of the EMR system can restrain the inherent, collaborative, and social nature of clinical work. In this paper, we present the important factors to consider in designing EMR systems. Residents and attendings usually perform different types of tasks. The residents' note-intensive tasks are not currently supported by the EMR as well as the attendings' clinical-decision tasks. Thus, the specific documenting locations, the medium, and the information needed to complete note-intensive tasks should be studied and identified when designing EMR systems. Defining explicit roles and responsibilities is crucial in medical work where collaboration plays a key part in the patient care process. The EMR system should be able to balance flexibility and interruption in work practices to better manage the complex nature of the medical work. The design of the EMR system also needs to understand and appropriately reflect the routines of the system's users to support necessary interactions in the collaborative work environment. These factors lead us to realize the EMR system should be designed based not solely on the way records are used, but also taking into account how records are charted in view of existing work practices and how the charting process alters the work environment and patient care process. As our study suggests, even an apparently trivial design issue may lead to a series of consequences on doctors' work practices – consequences directly mediated by the system design, and which may affect the other collaborators whose work is reliant on doctors' work. Many of the collaborative and organizational effects can be alleviated by redesigning the information systems to fit the nuanced work practices which were previously unnoticed in the design process.

Authors' contributions

Sun Young Park performed the data collection, conducted the initial data analysis, and led the writing of the manuscript.

So Young Lee contributed substantially to the data collection, data analysis, and to the writing of the manuscript.

Dr. Yunan Chen supervised the data collection and data analysis and contributed substantially to the writing of the manuscript.

Conflict of interest statement

None of the authors have any financial conflicts or other conflicts of interest with this work.

Acknowledgments

Summary table

What was already known before	What the study added to our knowledge
• While implementing IT systems in healthcare field has led to many benefits, such as easy access and accurate documentation in patients' records, reduced medical errors, and billing management, they are often associated with many unintended consequences such as increased documentation time, incompatibility with clinical workflow, and system-introduced errors in patient care. • The EMR deployment influences on doctors' documentation processes, but it also has social consequences, affecting their interactions with nurses and patients.	• Our study associates the social and organizational consequences of EMR with the actual design of the system, and we suggest design guidelines for electronic documentation systems which could alleviate these issues: (1) design to support note-intensive tasks mainly affecting residents' work, (2) design to define roles in collaborative work between residents and attendings, and 3) design to the balance flexibility and interruption.

REFERENCES

[1] R. Steinbrook, Health care and the American recovery and reinvestment Act, New England Journal of Medicine 360 (2009) 1057–1060.

[2] J. Menke, C. Broner, D. Campbell, M. McKissick, J. Edwards-Beckett, Computerized clinical documentation system in the pediatric intensive care unit, BMC Medical Informatics and Decision Making (2001) 1–3.

[3] J.S. Ash, D.F. Sittig, E.G. Poon, K. Guappone, E. Campbell, R.H. Dykstra, The extent and importance of unintended consequences related to computerized provider order entry, Journal of American Medical Informatics Association 14 (2007) 415–423.

[4] W.R. Hersh, The electronic medical record: promises and problems, Journal of the American Society for Information Science 46 (10) (1999) 772–776.

[5] D.W. Bates, M. Ebell, E. Gotlieb, J. Zapp, H.C. Mullins, A proposal for electronic medical records in U.S. primary care, Journal of the American Medical Informatics Association 10 (1) (2003) 1–10.

[6] L. Wilcox, J. Lu, J. Lai, S. Feiner, D. Jordan, Physician-driven management of patient progress notes in an intensive care unit, in: CHI Annual Symposium Proceedings, 2010, pp. 1879–1888.

[7] R.H. Dykstra, J.S. Ash, E. Campbell, D.F. Sittig, K. Guappone, J. Carpenter, J. Richardson, A. Wright, C. McMullen, Persistent paper: the myth of going paperless, in: AMIA Annual Symposium Proceedings, 2009, pp. 158–162.

[8] J.S. Ash, D.F. Sittig, E. Campbell, K. Guappone, R. Dykstra, An unintended consequence of CPOE implementation: shifts in power, control, and autonomy, in: AMIA Annual Symposium Proceedings, 2006, pp. 11–15.

[9] G. Fitzpatrick, Integrated care and the working record, Health Informatics Journal 10 (2004) 291–302.

[10] P.J. Embi, T.R. Yackel, J.R. Logan, J.L. Bowen, T.G. Cooney, P.N. Gorman, Impacts of computerized physician documentation in a teaching hospital: perceptions of faculty and resident physicians, Journal of American Medical Informatics Association 11 (2004) 300–309.

[11] L. Poissant, J. Pereira, R. Tamblyn, Y. Kawasumi, The impact of electronic health records on time efficiency of physicians and nurses: a systematic review, Journal of the American Medical Informatics Association 12 (2005) 505–516.

[12] Y.Y. Han, J.A. Carcillo, S.T. Venkataraman, R.S.B. Clark, S. Watson, T.C. Nguyen, H. Bayir, R.A. Orr, Unexpected increased mortality after implementation of a commercially sold computerized physician order entry system, Pediatrics 116 (2005) 1506–1512.

[13] S.T. Rosenbloom, J. Grande, A. Geissbuhler, R.A. Miller, Experience in implementing inpatient clinical note capture via a provider order entry system, Journal of the American Medical Informatics Association 11 (2004) 310–315.

[14] J.S. Ash, M. Berg, E. Coiera, Some unintended consequences of information technology in health care: the nature of patient care information system-related errors, Journal of American Medical Informatics Association 11 (2004) 104–112.

[15] A.L. Strauss, S. Fagerhaugh, Social Organization of Medical Work, Transaction Pub, 1997.

[16] M.L. Markus, Power, politics, and MIS implementation, Communications of the ACM 26 (1983) 430–444.

[17] W. Pratt, C.R.M.C. Reddy, D.W. McDonald, P.T. Hornoch, J.H. Gennari, Incorporating ideas from computer-supported cooperative work, Journal of Biomedical Informatics 37 (2004) 128–137.

[18] C. Tang, S. Carpendale, An observational study on information flow during nurses' shift change, in: Proceedings of the SIGCHI Conference on Human factors in Computing Systems, 2007, pp. 219–228.

[19] S.R. Barley, Technology as an occasion for structuring: evidence from observations of CT scanners and the social order of radiology departments, Administrative Science Quarterly 31 (1) (1986) 78–108.

[20] M. Berg, Implementing information systems in health care organizations: myths and challenges, International Journal of Medical Informatics 64 (2–3) (2001) 143–156.

[21] J.K. Piasecki, E. Calhoun, J. Engelberg, W. Rice, D. Dilts, D. Belser, D. Aronsky, I. Jones, D. Mason, B. Stead, Computerized provider order entry in the emergency department: pilot evaluation of a return on investment analysis instrument, in: Proceeding of AMIA Annual Symposium, 2005, p. 1081.

[22] J. Richardson, J. Ash, The effects of hands free communication devices on clinical communication: balancing communication access needs with user control, in: Proceeding of AMIA Annual Symposium, Washington DC, 2008, pp. 621–625.

[23] M. Hardey, S. Payne, P. Coleman, 'Scraps': hidden nursing information and its influence on the delivery of care, Journal of Advanced Nursing 32 (2000) 208–214.

[24] B. Kaplan, Addressing organizational issues into the evaluation of medical systems, Journal of American Medical Informatics Association 4 (1997) 94–101.

[25] X. Zhou, M.S. Ackerman, K. Zheng, I just do not know why it is gone: maintaining informal information use inpatient care, in: Proceedings of CHI 2009, 2009, pp. 2061–2070.

[26] T.H. Payne, G. Graham, Managing the life cycle of electronic clinical documents, Journal of American Medical Informatics Association 13 (2006) 438–445.

[27] T.H. Payne, A.E. tenBroek, G.S. Fletcher, M.C. Labuguen, Transition from paper to electronic inpatient physician notes, Journal of American Medical Informatics Association 17 (2010) 108–111.

[28] H. Laerum, T.H. Karlsen, A. Faxvaag, Effects of scanning and eliminating paper-based medical records on hospital physicians' clinical work practice, Journal of the American Medical Informatics Association 106 (2003) 588–595.

[29] S. Phansalkar, J. Edworthy, E. Hellier, D.L. Seger, A. Schedlbauer, A.J. Avery, D.W. Bates, A review of human factors principles for the design and implementation of medication safety alerts in clinical information systems, Journal of American Medical Informatics Association 17 (2010) 493–501.

[30] J.S. Ash, D.W. Bates, Factors and forces affecting EHR system adoption: report of a 2004 ACMI discussion, Journal of American Medical Informatics Association 12 (2005) 8–12.

[31] J. Aarts, J.L. Callen, E.W. Coiera, J.I. Westbrook, Information technology in health care: socio-technical approaches, International Journal of Medical Informatics 79 (6) (2010) 389–390.

[32] C. Heath, P. Luff, Documents and professional practice: 'bad' organizational reasons for 'good' clinical records, in: Proceedings of CSCW 1996, 1996, pp. 354–363.

[33] M. Berg, J. Aarts, J. van der Lei, ICT in health care: sociotechnical approaches, Methods of Information in Medicine 42 (4) (2003) 297–301.

[34] H. Beyer, K. Holtzblatt, Contextual Design: Defining Customer-Centered Systems, Morgan Kaufmann, 1997.

[35] S. Thielke, K. Hammond, S. Helbig, Copying and pasting of examinations within the electronic medical record, International Journal of Medical Informatics 76S (2007) S122–S128.

[36] T.H. Payne, M. Perkins, R. Kalus, D. Reilly, The transition to electronic documentation on a teaching hospital, in: Proceeding of AMIA Annual Symposium, 2006, pp. 629–633.

[37] D.L. Roter, M. Stewart, S.M. Putnam, M. Lipkin, W. Stiles, T.S. Inui, Communication patterns of primary care physicians, Journal of the American Medical Informatics Association 277 (4) (1997) 350–356.

[38] D.L. Roter, J.A. Hall, D.E. Kern, R.B. Barker, K.A. Cole, R.P. Roca, Improving physicians' interviewing skills and reducing patients' emotional distress, Archives of Internal Medicine 155 (17) (1995) 1877–1884.

[39] J.A. Hall, D.L. Roter, N.R. Katz, Meta-analysis of correlates of provider behavior in medical encounters, Medical Care 26 (7) (1998) 657–675.

[40] S. Vikkelsø, Subtle redistribution of work, attention and risks: electronic patient records and organizational consequences, Scandinavian Journal of Information Systems 17 (1) (2005) 3–30.