

Local–Universality: Designing EMR to Support Localized Informal Documentation Practices

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ABSTRACT

In this paper, we describe a practice that is common across multiple heterogeneous contexts but enacted differently depending on the unique constellation of resources and demands present in each local context. Using the case of informal documentation practices in two departments of a single hospital, Emergency and Labor & Delivery, we describe how clinicians in each department develop contextualized informal documentation practices after deployment of a new EMR system. We describe three underlying functions of informal documentation that are inherent to the practice of medical personnel: "memory work," abstraction work," and "future work." We then find that the newly deployed EMR technology does not support these kinds of work. We argue that hospital documentation work systems should be designed with an eye to such universal work practices, while keeping in mind that the effectiveness of informal documentation practices is rooted in its adaptive and flexible deployment in heterogeneous work settings.

Author Keywords

Documentation; Informal Documentation Practices; Locality; Universality; Electronic Medical Record (EMR)

ACM Classification Keywords

H.0; K.4.3; J.3

INTRODUCTION

A hospital is a complex organizational system comprised of dozens of medical and administrative units, each with a unique purpose and set of activities. Proper functioning of a hospital requires the alignment of the activities of multiple departments together. Researchers in CSCW have long been concerned with the development of Health Information Technologies, such as Electronic Medical Record (EMR) systems, to support hospital workflow. EMRs are designed to serve as comprehensive information infrastructures that include both the medical chart and a key component of the hospital work system [5], while

simultaneously serving other multiple functions such as scheduling, entering orders, and retrieving results. This comprehensive approach promotes legibility and access to information as well as the standardization of workflows among heterogeneous departments across the hospital [22]. Overall, the centralization of patient information and standardization of work coordination enabled by a shared computer platform is expected to enhance the quality, safety, and efficiency of health care practices [1] and result in cost savings [24].

Individual departments have unique goals, tools, cultures, and workflows, making centralization and standardization difficult to achieve in practice. We borrow the term "local-universality" from Timmermans & Berg (1997) [35], who argue that standardization of artifacts such as protocols is only achieved through local adaptation of universal standards. However, we apply the term differently. In our conceptualization, local-universality applies to a *type of practice* that has stable characteristics in multiple local settings rather than a particular artifact. We employ this concept to study clinicians' informal documentation practice. Our analysis reveals that although different local departments and user groups localize informal documentation to their particular context, there are common, universal types of work in the informal documentation practice across the hospital, which are not currently supported by the EMR. Conceptualizing informal documentation as a "local-universality" allows us to analyze both the stable and flexible characteristics of this practice, which in turn will help us think about how to design computer-supported work systems that promote, rather than interfere with, informal documentation.

Although creating a "paperless" system was a goal of EMR implementation in general, researchers note that creating paperless electronic workflows through EMRs is very difficult and "paper persistence" post-implementation is pervasive in hospitals [17]. Paper persistence has been seen as a problem arising primarily from incomplete integration of health information technologies (HIT) with existing work systems. Campbell et al. [8] and Chen [9] give examples of problematic paper persistence such as using printouts from an EMR for documenting and transposing information back and forth between computer and paper forms. Unlike previous studies on incomplete integration of HITs, we focus on informal documentation practice and see the persistence of paper not as a problem in and of itself,

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but as evidence of the importance of informal documentation practice and a means through which we can better understand the function of informal documentation in hospital departments. We define "informal documentation" as documentation activities that take place outside the purview of the official EMR system. A key feature of informal documentation artifacts is that they are *not archived after use*. Unlike "formal documentation," informal documentation is only used as part of the practice of doing work, not as part of an official record of the work that was done. We define "formal" documentation as any documentation, paper or electronic, that is archived and thus forms part of an account of care that is retrievable and accountable for organizational, regulatory, or legal purposes.

In this paper, we present findings from an ethnographic study at a large teaching hospital to examine the informal documentation that took place in *two local departments*, in response to newly imposed formal documentation requirements presented by implementation of an EMR system deployed across the hospital. Specifically, we focused on the local practices for informal documentation in two separate departments – Emergency Department (ED) and Labor and Delivery (L&D). Although in the same hospital, these departments are radically different: ED is driven by time pressure. Multiple patients are managed by caregivers at once and the objective is to stabilize patients and discharge or transfer them to the care of another unit. In contrast, L&D specializes in a single medical domain and one-to-one patient care through the entire trajectory of labor, birth, and recovery. Our findings reveal that despite the different nature of work taking place in each department, medical workers engaged in three universal informal documentation practices, which we call *memory work*, *abstraction work*, and *future work*. These informal documentation practices arise in response to universal needs and goals in heterogeneous healthcare contexts, but take different forms depending on the local work processes, requirements, and resources. Further, we provide suggestions on how to design for such practices in future EMR system design.

RELATED WORK

The complexity of the healthcare field has been widely noted by the HCI community. Previous research has exposed a variety of issues affecting the successful design and implementation of HIT in medical workplaces, such as temporality in coordination [32] spatiality in collaboration [4], compatibility in workflows [9], and breakdowns in communications [32]. This rich stream of research indicates the magnitude of the challenges presented by designing systems for the healthcare field. Because of these unique challenges, researchers note a multitude of problems with current designs of large HIT systems. Despite expected benefits such as easy access to patients' records [23, 37] and increased quality of patient care [23], unintended consequences have also been reported, including increased

documentation time [27, 31], medical errors [2], and increased mortality [19]. Others also have noted that system design has unexpected impacts on clinical work processes and practices. For example, electronic documentation changes the workflow [11,13], alters the structure of physician notes [13], and alters the physical layout of work practice [26].

Medical work is highly complex and requires coordination among multiple heterogeneous individuals and departments [34]. This creates tension when attempting to achieve meaningful use of a system designed for an entire hospital while also finding congruence with the unique constellation of practices, routines, and requirements present in each individual department [22]. Given the dynamic, contextual nature of healthcare environments, it is very challenging to design universal information systems that serve as functional work infrastructures and support the intricate and variegated nature of medical work. Because of this, recent studies assert successful EMR systems must support local variations in workflow [3] and point to the inability for local departments to customize the EMR to their own needs and existing work structures [7].

One workflow issue noted in prior studies is the persistent use of paper despite implementation of an electronic system designed to eliminate paper documentation [8,12,18]. Much research shows that clinicians deploy working records [15], nursing working documents [38], provisional information [20], transitional artifacts [9], and personal notes [25]. These paper-based informal documentation practices allow clinicians to create flexible working documents that meet the needs for records to be provisional, informal, private or hidden [16, 38] and facilitate care delivery [20] that is timely and responsive [15]. Information documented on these paper artifacts is locally evolved, maintained, and used to support delivery of care. Dykstra et al. [12] argue that the role of paper will change from an archival medium to an active medium for communication, filling gaps left by information technologies.

Much of the literature on informal documentation asserts that these practices arise from insufficient design of clinical documentation systems. It has been argued that existing computerized systems often misrepresent the use of paper-based medical records [18], lack the ability to document and use informal and provisional information [20, 38], and lack the ability to support clinicians' tailoring, presenting, and augmenting clinical information based on their roles and preferences [15]. However, these studies have not yet addressed the specific issues of informal documentation use that arise due to the local and contextual nature of work practice.

To understand the dual nature of informal documentation practice as both local and universal, our paper has two primary aims:

1. To explore how informal documentation is used and understand how informal documentation is adapted and deployed in different contexts to support distinctly different work practices.
2. To identify and describe the commonalities in informal documentation practices employed in different contexts.

RESEARCH METHODS

This study was carried out at a large teaching hospital located in the United States. Our field site is a diverse organization with dozens of departments, employing more than 3,500 personnel and serving for more than 300,000 outpatients visits and nearly 17,000 inpatients visits per year. We chose to compare the ED and L&D since these two departments present uniquely distinct work practices.

Setting

Emergency Department (ED)

The primary goal of ED care is to promptly stabilize patients' medical problems and make decisions to either discharge or admit patients; if patients are admitted, ED clinicians must choose the appropriate department and transfer the patient's care. The general ED care process consists of short patient care trajectory¹ ranging from 1-2 hours to 1-1.5 days. In addition, ED deals with a wide variety of illnesses, which range from 1-2 hours of simple care (e.g. for patients needing stitches or patients presenting with influenza) to more serious exams (e.g., patients requiring an MRI or CT scan requiring specialist diagnosis) or the treatment of life threatening injuries.

Labor and Delivery (L&D)

The primary goal of L&D is to safely care for a mother and baby throughout the entire trajectory of labor, birth, and recovery, and it is specialized in only one area of medicine (obstetrics). In addition, patients stay much longer in L&D than ED ranging from 1-2 days to up to 12 weeks or more if a patient is admitted for antepartum care². The L&D department has 14 beds and approximately 55 nurses. About 1,000 deliveries per year occur in L&D. Due to legal pressures and the nature of the work, documentation requirements in L&D are much more intense than ED and a larger quantity of information must be recorded. The physical layout consists of a central nursing station with computers for documentation surrounded by several patient rooms, each of which is equipped with computer terminals for in-room documentation.

Data and Data Collection

We conducted a comparative qualitative field study using ethnographic methods. All data was collected by the first

two authors, who conducted in-depth observations and interviews with clinicians in each department. The goal was to gain an in-depth contextual understanding of how ED and L&D clinicians perform their documentation work, as well as the ways different artifacts were used to support these activities. We followed key personnel and artifacts, such as patients' paper charts and admission and discharge processes, to comprehend the general workflow of ED and L&D from various perspectives. We also observed various staff meetings and trainings pertinent to documentation.

In total, 630 hours (230 in ED and 400 in L&D) of observation was conducted over a period of 2 years. Each observation session ranged between 2 and 15 hours at all times of day and night, including weekends. In the ED, we studied 19 doctors, 20 nurses and interviewed 23 clinicians. In the L&D, we shadowed 25 nurses and conducted interviews with 11 nurses and a focus group with 12 nurses. Interviews were recorded and transcribed for analysis.

After completing observations and interviews, we reviewed the data collected in the study to understand clinicians' documentation behaviors in both the ED and L&D. Data were analyzed using qualitative data analysis to identify themes. After informal documentation was chosen as the main theme, we followed a process of comparing informal documentation artifacts from each unit. We coded types of information present on different artifacts, such as "future work," then re-analyzed artifacts with these categories in mind, thus refining and defining *categories* of informal documentation and noting similarities and differences between the two departments. We also coded sections of field notes, including conversations held with participants during the course of field work, related to informal documentation for further insight in to how clinicians in each department use the informal documentation in practice. During this process, we wrote extensive memos about key themes we saw emerging from the data, which we later refined through the process of writing. During data analysis, findings were presented to participants in a series of informal conversations to contest findings and clarify pre-conceptions [25].

FINDINGS

Recently a comprehensive and large-scale EMR system was implemented at our field site. The EMR was custom-designed for our field site and has been used in all the departments across the hospital for about a year. The EMR serves as an official record system for the entire hospital and the information documented in the EMR is archived and stored digitally. Although the EMR is expected to result in a "paperless" hospital work system, nonetheless, consistent with past findings [9,15,20, 26], we observed clinicians in both ED and L&D used papers extensively after implementation, which we observed was because of the importance of informal documentation to support the performance of medical care. In this section we first describe the differences between formal and informal

¹ A "trajectory" is the entire course of a disease and the associated work in its different stages and phases [Strauss et al., 1986]

² Hospitalized bedrest due to complications with a pregnancy.

documentations, and then describe informal documentation use in ED and L&D.

Formal and Informal Documentation

In this paper, we distinguish between practices for “formal” documentation that is entered into the official medical record, and practices for “informal documentation” that are not archived in permanent records.

- Formal documentation refers to the documentation that is archived or stored (either physically or digitally) and is thus auditable by agents either within or outside the organization. E.g. all documentation that occurs in the EMR, L&D bedside flowsheet program, ED nurses’ flowsheet and nursing notes.
- Informal documentation is documentation that is discarded and not stored as permanent records. E.g. single-patient worksheets, annotated daily rounds sheets, triage note print-outs, as well as notes kept on scraps of paper or jotted elsewhere.

In our field sites, informal documentation was primarily used by ED doctors and L&D nurses. Although doctors and nurses are different types of users, we chose to focus on L&D nurses and ED physicians because these were the user groups who engaged in informal documentation most intensively in each department. Our observations revealed that informal documentation practices were used universally for needs that seem to be fundamental to the emergent organization of medical work. By analyzing the informal documentation practices in each department and comparing informal documentation practices across the two departments, we identified different (*local*) needs and common (*universal*) usages for the informal documentation practices developed by ED doctors and L&D nurses.

Informal Documentation Use in ED

Two primary rationales underlie the unique informal documentation practices we observed in ED: time pressure and the need to care for multiple patients at once. Compared to other units in the hospital, ED is a time-pressured environment with short patient turnaround time and on-going care for multiple patients. Despite this short care duration, the workload in ED is very heavy. During rush hours (e.g. weekend evenings and Monday mornings), ED doctors often treat several patients in a row without having time to chart between patients. Moreover, doctors constantly perform time-sensitive coordination work to handle multiple patients care and collaborate with different patient care team members, such as bedside nurses, translators, technicians, admitting residents, and specialists.

ED doctors’ informal documentation practices arose naturally from the clash between the constraints imposed by the EMR and the unique nature of ED work. Prior to EMR deployment, ED doctors used paper records for charting work at the patients’ bedside, thus completing much of their documentation work during an exam. Doctors entered patient rooms with charts in hand, filled them out during the

initial consultation, and carried them as they moved around the ED. However, after EMR deployment, completing charting with paper records was no longer possible. It was not possible to complete documentation efficiently with the EMR. ED doctors realized that in contrast to the paper charts, the EMR required them to document very detailed patient information. Furthermore, although ED doctors had access to wall-mounted bedside computers, they disliked typing and paying attention to a computer in front of their patients. As a result, ED doctors began using paper personal notes to bridge the gap, allowing them to complete detailed documentation in the EMR after they had left the patient’s room. Now, before doctors see a new patient, they either print a triage note from the EMR system or prepare a blank paper to use for personal notes. Doctors often fold papers in half or $\frac{1}{4}$ and carry them in their pockets until patients are discharged or their shift ends. ED doctors found that the use of personal notes was particularly helpful in transferring information from the doctors’ room to new patient rooms, since they could quickly preview patient information on their way to meet patients. This informal documentation practice was initiated by a few doctors and later adopted by all ED doctors (Figure 1).

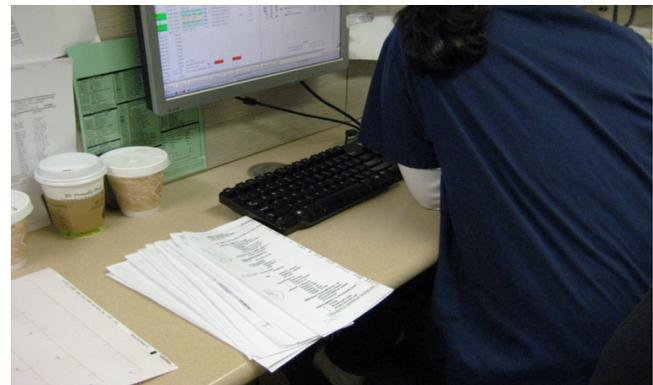


Figure 1. Several personal notes (triage copies) used by ED doctor when charting at computer.

In ED, informal documentation was primarily used for supporting what we term *memory work* – the information that needs to be saved and transferred from the bedside to the EMR. ED doctors care for multiple patients at the same time and have many ongoing tasks that cannot always be instantly logged in the EMR. After the EMR rollout, ED doctors could no longer conduct the bulk of their initial documentation at the bedside and they found it impossible to rely solely on memory when charting information later. Moreover, since ED doctors often saw multiple patients in a row and were unable to chart at the bedside, a large backlog of information was created. To support memory work, ED doctors recorded brief notes on papers before or during the bedside consultation then used these paper notes as a basis for the follow up EMR-based formal documentation.

Informal documentation was also employed for *abstracting key information* from the EMR system. As they managed multiple patients at a time, ED doctors found it was

essential to be aware of the “big picture” – knowing what is going on with every patient they manage. Instead of spending time checking information in the detailed EMR record, doctors narrowed down the extensive information stored in the EMR to a simplified information snapshot using informal documentation. On personal notes, doctors jotted down only basic information for each patient (e.g. age, chief complaints, medical history), and they frequently edited or updated their notes to record new procedures and medications. Some doctors drew tables to organize multiple patients’ information at once. In our study, almost all ED doctors felt the need to remain aware of basic information about all the patients they managed. Informal documentation allows them to abstract key information in a personal, portable, and easy to read manner.

ED doctors also utilized informal documentation to facilitate *future planning*. In the ED, rapid decisions and coordination for next steps in patient care is important for quick turnaround and efficient patient treatment. Each of the multiple patients managed by an ED doctor at any given time has a unique care trajectory. In order to coordinate all medical tasks in a timely manner within this extremely complex environment, ED doctors must remain continuously informed of each patient’s status and the possible future actions they may need to take, and they must coordinate these actions so they can manage their own time and attention to care for multiple patients at once.

In summary, the informal documentation practice was created and used to help ED doctors’ memorize on-going information, abstract key information, and planning future actions. ED doctors used informal documentation to support their unique work practices that were not supported by current EMR documentation.

Informal Documentation Use in L&D

While ED work is characterized by a routine of stabilize-and-transfer, L&D is characterized by the detail-driven work of caring for a mother and baby throughout the course of labor and childbirth. The role of nurses is much different, as nursing care is one-to-one during the intense phases of labor, birth, and recovery. L&D nurses manage their patients very closely, as they monitor the health of mother and baby through labor and provide emotional support for mothers and families. They also often act as a “hub” who communicates and facilitates coordination among all of the other members of the obstetrical team. The informal documentation practices that have developed in L&D are thus uniquely suited to this context.

In contrast to ED, L&D nurses had a well-developed informal documentation practice prior to deployment of the EMR. Each evening at 7PM and each morning at 7AM, the outgoing nurses would print a worksheet from the older-generation computer order entry system. This worksheet contained patient information as well as a list of all active orders at the time of shift change. As each incoming nurse received their patient assignment from the charge nurse,

he/she would report to the outgoing nurse for that patient, who would give them the newly printed worksheet before beginning a lengthy handoff conversation. During handoff between the L&D nurses, the outgoing nurse gave the incoming nurse a description of the medical history and current condition of the patient, along with many detailed narrative descriptions of the patient’s labor and how it was progressing and the story of the patient’s care so far. The incoming nurse would often make copious notes on the patient worksheet during handoff, and then continue to use the worksheet to make notes, organize tasks, and refer to key elements of the patient’s story throughout her shift, until handing the patient off to another nurse. Many nurses would use the worksheets to create customized schedule of tasks that needed to be completed for their patients using a series of lines and checkboxes along with the times that different orders were supposed to be carried out, thus facilitating proper execution of orders and serving as a memory aid for the nurses.

However, after EMR implementation, the worksheets were no longer printed automatically, and it was not possible to print a worksheet that contained a list of active orders. The absence of a worksheet presented a disruption in the nursing work in L&D. One nurse described it simply as follows: “*I just feel blind without having the orders, and the worksheet. It’s like I don’t have eyes.*” With the EMR, nurses were able to log into the system to check orders, but they did not like doing so in the patient’s room, and often had difficulties with the logins. Nurses disliked having to leave the room to look at orders, and the new “worklist” function on the EMR program was not as convenient or as malleable as the hand-drawn schedules for task completion that they used to draw on the worksheets. The lack of a worksheet impeded the nurses’ ability to engage in *memory work* both during handoff and throughout the shift. L&D nurses experienced a disconnection between the patient and the information that they needed to take care of the patient. Nurses also realized that they had used the worksheet as much more than a reference sheet for orders. The worksheet served several other valuable functions, and they disliked having the worksheet taken away from them. L&D nurses soon compensated by creating their own worksheets using blank pieces of paper to keep track of active orders and other key pieces of information. Soon after, nurses realized that although they could not print a worksheet from the EMR, they could continue to print a worksheet from the older order entry program. The function on this program was still accessible, although they were not supposed to use it and it no longer provided a list of orders. The importance of the worksheet in L&D was evident in the commonly used nickname for it – nurses referred to the worksheet as their “brain.” When nurses needed a piece of information, such as when a medication was due or what a patient’s weight was, they often said, “*Where’s my brain?*” or “*Let me grab my brain!*” while fishing the worksheet out of their pocket or locating it on the counter of the nurse’s station.

Therefore, worksheets function as “eyes” and “brains” which allow nurses to remember orders and other key information while interacting directly with patients at the bedside.

Informal documentation was also used as a way to *abstract key information* from the highly detailed patient information that resides in multiple information systems, including the EMR. However, the granularity of the information L&D nurses collected was much finer than the information used in the ED. Instead of summarizing multiple patients’ conditions on one piece of paper as ED doctors did, L&D nurses utilized one sheet per patient. An L&D worksheet contains detailed information about a patient’s history and progress, even for patients’ basic information, such as weight, body mass index, admission date, and other details. For example, during our observation, nurses made notes about patients’ position and breathing, such as “*wheezes on left side*”. This detailed but abstracted and readily accessible artifact not only allowed L&D nurses to see a clear, organized one-page overview for each patient, but also helped them to report a patient’s condition to other team members. Therefore, informal documentation allows L&D nurses to control the granularity of the information they abstract and avoid checking the entire patient chart every time they need a piece of information.

Informal documentation practice also aided L&D nurses’ tracking of possible future plans for the patient care trajectory. Predicting future care trajectories and their associated tasks is essential for L&D nurses because they need to carry out these orders in relation to all of the other tasks they are handling and the resources available on the unit. While ED doctors are coordinating multiple patients in relation to each other, L&D nurses must anticipate possible future tasks so they can anticipate which team members they need to contact and which materials they may need to gather. Informal documentation allows nurses to control the relationship between all the tasks to be performed in the future and to visualize the respective stage of completion, at a single glance. It also enables a safety check, so that they do not forget tasks by having them planned on papers.

To summarize, our analysis revealed intensive use of informal documentation among L&D nurses. The nature of the informal documentation that took place as well as the specific informal documentation artifacts developed by L&D nurses were quite different than those observed in the ED. L&D nurses had an increased need for specificity of information and details important to the patient’s narrative, as detail-driven long-term care calls for ongoing and long-trajectory. L&D nurses also used worksheets intensively to remember and organize tasks to be carried out after the disruption caused by EMR-based formal documentation, which did not function adequately as a brain or eyes for L&D nurses. This function was not observed to the same degree among ED physicians, due both to the different

nature of ED work and the occupational tasks associated with physician and nursing work. However, we observed many commonalities in both informal documentation practices, which we describe next.

Universal Informal Documentation Practice

Although the two departments are very different, informal documentation serves multiple common needs across both departments. These needs are motivated by the general characteristics of the health care practices shared by both ED and L&D. These include the high complexity of the work environment; the fact that many interdisciplinary providers and staff must work within this environment together and must coordinate their actions to care for patients; and the fact that work is highly contextual and responsive. We identified three main categories of universal needs served by informal documentation practices: *memory work*, *abstraction work*, and *future work* (Figure 2). In this section we describe how current informal documentation practices are uniquely suited to meeting these needs and bridging the gaps caused by EMR.

Memory work

The first universal use of informal documentation is to aid clinicians’ memory work by managing the temporality of the patient chart. Doctors and nurses are expected to care for and attend to their patients on an ongoing basis, and also expected to “keep up” with their documentation work. In essence, clinicians must care for both the patient and the chart and choreograph these two streams of work together into one coherent flow of actions [29]. However, this is not always possible, particularly given the unpredictable and complex nature of medical work. For example, when ED doctors have to see 3-4 patients in a row at busy times and receive verbal updates from nurses in the hallways, this ongoing information could easily be forgotten before it is documented. Information is captured using informal documentation before it is forgotten so that it can be documented in the formal patient record at a later time. Similarly in L&D, key pieces of information are produced on an ongoing basis, but a nurse’s hands are often engaged elsewhere and he/she finds it impossible to chart in the EMR “in real time,” although this is the expectation. If information is not written down, it is often quickly forgotten. A common strategy for managing both the patient and the chart is jotting down a few details on the accessible paper worksheet and completing charting details later, when there is a lull in patient work. This practice is known as “back charting” in the hospital, and it is discouraged. However, our observations reveal that using informal documentation to engage in strategic back-charting is actually a crucial practice that enables L&D nurses to stay focused on the patient during intense phases of work [29].

Lastly, informal documentation use supports memory work by retaining information that is not ready to be charted. For legal and regulatory purposes, EMR documents only factual

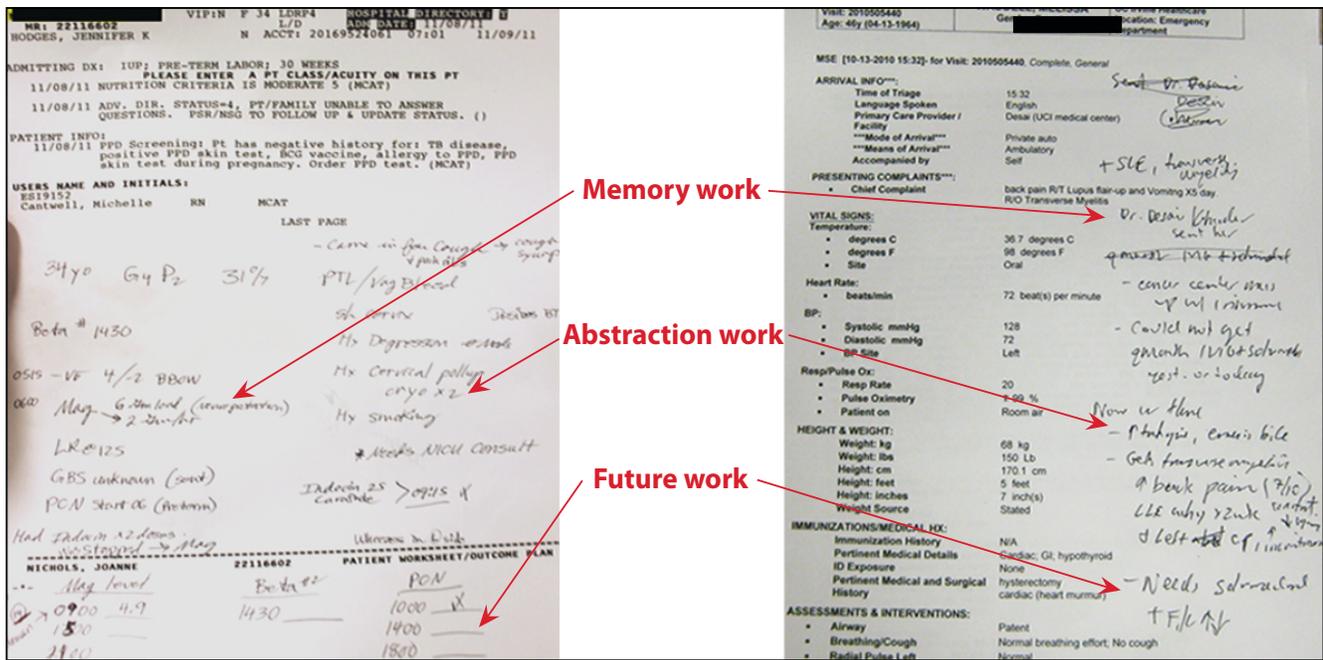


Figure 2. Informal documentation artifacts: triage note copies used by ED doctor (right) and worksheet used by L&D nurse (left)

information, not conjecture. Since doctors’ diagnosis work is mostly hypothesis-driven, doctors cannot document suspected diagnoses in the EMR unless they receive lab or image results, which corroborate their suspicions. Thus, memory work serves to help doctors record items they cannot officially document.

Abstraction work

Doctors and nurses use informal documentation to create abstracted accounts from a patient’s larger medical chart. An abstracted account provides a quick overview of a patient’s situation. Formal EMR documentation practices collect of a huge amount of information about a patient and provide a high level of detail about the patient. However, in real medical practice, clinicians often need an information source that contains only the most important facts to allow easy and quick access. For example, an ED doctor entering a room may only want to know chief complaints or lab results. In our study, ED doctors needed highly abstracted notes that presented an overview of multiple patient situations efficiently, whereas L&D nurses required a more detailed degree of information. The degree of granularity of this abstraction in informal documentation varied depending on departments. We acknowledge that differences between the work of nurses and physicians might have influenced the degree of abstraction. We believe the more important point is that even though there is variation between the informal documentation practices of these different user groups, these practices have stable underlying functions. Creating abstractions of the lengthy formal documentation stored in the EMR also help clinicians to track key occurrences, such as major procedures or lab results, and manage their workloads.

Similar findings have been reported in separating informal notes from formal note content through tagging the important items [37]. Since documenting information in the EMR requires users to document in a precise, clear, and complete manner, key information is often buried in the lengthy and extensive patient records. To manage and coordinate multiple tasks, doctors and nurses often flag pieces of information to rank items in terms of importance. Even though the design of EMR uses red flags to draw clinicians’ attention to important information, clinicians cannot control what information they want to flag. Instead, it is predefined by the system and is universally designed across the entire medical center. Thus, informal documentation provides clinicians control and flexibility by allowing them to create their own system by flagging and prioritizing key information.

Future work

Another function of informal documentation is keeping track of possible future steps – commonly known as “trajectory work.” Trajectory work is essential to medical practice [34]. In contrast to abstraction work where glancing at a quick overview of current patient information, trajectory work involves anticipating actions a clinician may need to take in the future depending on how a patient’s trajectory unfolds. Thus, clinicians have to note down possible future actions that may need to be taken based on the patient’s current situation. This forecasting allows clinicians to prepare for upcoming tasks by prepping equipment for possible procedures, and checking available resources, hopefully preventing possible errors due to failure to anticipate an emerging situation. However, this future planning work is not appropriately supported by the

current EMR design. In our study, we observed that doctors and nurses often used informal documentation to note possible future problems or events. For instance, an L&D nurse wrote “NICU consult” and drew an asterisk to remind herself to schedule a consultation for a patient later. This piece of information also alerted her to other tasks that might be required of her in the future should the baby be admitted to the NICU. Similarly, an ED doctor circled one of the lab orders for a patient to remind himself to check if the result was positive. This information would further affect the follow up care plans, such as where to admit this patient or who to call for consultations. Although nurses and physicians find it necessary to constantly plan for a wide range of possible future events, clinicians do not wish to enter information into the official record that may or may not be factual in the future.

Additionally, information documentation provides an overall picture of the patient trajectory by serving as a visual map so that clinicians can coordinate future tasks efficiently. The visual maps of tasks on paper notes were used as a reminder for clinicians of next steps, such as the task grids L&D nurses often drew on paper notes to indicate all the tasks need to be done and the stages they are currently in. Thus, mapping using informal documentation is more contextual than the task display on the EMR.

DISCUSSION

The EMR system at our field site was designed to serve as an information infrastructure supporting clinical documentation and other work activities in all departments across the entire hospital. However, our study found that the design of this EMR system does not support a key set of practices that are critical for clinical work – informal documentation practices. Informal documentation is necessary in the delivery of both medical and nursing care to sustain proper clinician documentation processes, and also serves as an artifact tailoring the formal EMR system to local work systems. In this section, we first discuss the need to re-conceptualize informal documentation as an essential practice for medical work that is often neglected by designers and administrators. Then, we consider informal documentation as a site for the development of practices that enable local users to exert control over universal infrastructures. We further discuss the need of rethinking the goal of EMR as it needs to successfully support informal documentation practice.

Redesigning for both Universality and Locality

Drawing on work from science and technology studies, processes of standardization and the creation of “universalities” must be examined through the lens of local practice. Thus, Timmermans and Berg [35] point out that successful standards only come into being as “local universalities.” They argue, “universality always rests on real-time work, and emerges from localized processes of negotiations and pre-existing institutional, infrastructural, and material relations.” That is, an artifact such as a

protocol, technology, or work infrastructure only becomes universal if it is successfully taken up by workers through local practices in multiple distributed work systems. We appropriate the notion of *local universality* but apply it to describe an *informal practice* rather than a *formal artifact*.

Informal documentation is not generally considered as an essential component of medical practice, as evidenced by the fact that designers of EMR systems do not include features to support informal documentation. Furthermore, administrators sometimes remove informal documentation artifacts (such as the worksheets of L&D nurses) from the work system without considering the impact this may have on medical personnel. In fact, our study shows the use of informal documentation is universal in both the ED and L&D departments, but the particular deployment of informal documentation varies depending on local contexts. The study uncovers that there are some striking similarities in informal documentation usage in both units even though the systems of work are quite different. We saw that clinicians in each department used informal documentation commonly for memory work, abstraction work, and future work. In each department, the informal documentation serves as an aid to the eyes, brain, and memory for providers to process, organize, and store the information necessary for patient care. This finding could help us understand the role of informal documentation in healthcare work systems in general, suggesting that informal documentation is fundamental to medical work.

However, discussing the use of informal documentation in general terms overlooks the multiplicity and complexity of informal documentation practices that occur in local departments. Although all departments come together in the service of the over-arching goal of providing high-quality patient care under the umbrella of a single hospital, each medical department in the hospital differs fundamentally from others since each has different medical specialties with very different functions [22]. This difference is evident in the description of work at our field site; informal documentation occurs differently in different departments. The comparison of informal documentation practices in the two separate departments shows that unique configurations of goals, contents, displays, practices, and requirements shaped the particular use of informal documentation. Therefore, the use of EMR across a healthcare organization requires designers to pay attention to not only universal use but also local use of informal documentation in order to allow the design to be flexibly adapted in several distributed localities.

Designers often focus on *artifacts* rather than *routines* - the patterns of action through which work is actually accomplished [28]. For example, when the new EMR system was deployed, although it was designed to produce clear and complete patient records as a documentation tool (*artifact*), it did not allow L&D nurses to print out worksheets which contain orders to mediate the actual work

process (*routines*). So the L&D nurses developed a new routine for obtaining a suitable artifact and creating a new worksheet. Therefore, the development of local routines is a source that ensures adaptability [26] and ongoing flexibility during and after the implementation of EMR systems, to fill the gap that EMR designs inevitably leave between localized user needs and the universally designed infrastructure.

Additionally, administrators often do not consider informal documentation practice as a crucial tool for medical and nursing work. The existence of several different interests at work in hospitals affects the ways that various individuals make use of the EMR system and must be taken into account when designing and redesigning the system. While clinicians working at the bedside may have a primarily work-based interest in EMR, administrators use EMR principally as an accounting and auditing system. In contrast to clinicians, who might favor an informal system coexisting with the EMR system, administrators might resist such a system since it works against the principles of accountability and audit (and hence the way that services are priced and billed). Thus, informal documentation has often been given a negative connotation [2, 6] at the level of administration and management. However, we find that informal documentation is a crucial nexus between universal and local infrastructures. It serves critical informal functions – such as for memory, abstraction, and future work – in clinicians' documentation work, even though these functions may not be immediately pertinent to administrators and managers.

Exerting Local Control

It is well-accepted in the HCI community that design should include participation and input from the end users of a system. The design of EMR systems is no exception. The EMR at our field site was implemented only after years of system testing and extensive training of all clinicians and staff. However, as noted earlier, designers of systems intended to serve as work infrastructures are never able to anticipate all of the problems that may arise. Also, users find it impossible to anticipate all of their needs and concerns until they are actually using a system [26, 30]. Systems need to be modified by users on an ongoing basis in response to changing circumstances and the specifics of a particular situation. When the hospital work system was paper-based, it was relatively easy for clinicians and staff to make modifications on an as-needed basis. Clinicians could cross out sections of forms or write things in at their discretion. If a form became obsolete, it could be discontinued without hassle; if the need for new information arose, the department could develop a new form and have it approved by a hospital committee. Of course, the EMR can be manipulated by clinicians in an informal way such as copying, pasting, and using comment boxes to type free information. However, it is difficult for local users to make fundamental changes to their work system. Although paper-based documentation systems do

not confer the same benefits as EMR for standardized workflow across departments (and, in the case of larger systems, across multiple hospitals), they are more malleable for clinicians and staff.

Additionally, EMRs introduce a level of oversight to which clinicians are unaccustomed. Through the use of warnings and restrictions, EMRs can exert pressure on users to follow certain protocols or procedures for carrying out tasks that clinicians previously were able to articulate using any number of different iterations. Finally, users often feel that EMRs are not flexible enough to allow them to control their own workflow – a flexibility that is needed to enable clinicians to accommodate the typical day-to-day variations and oddities that arise in the course of work in an organization where disruptions are constant. The design of EMRs thus exerts greater control over the actual actions that clinicians and staff engage in on a day-to-day basis, and the loss of flexibility and control over how to engage in clerical procedures can hamper medical practice [7,20, 38].

For this reason, Berg [6] argues that it is essential for EMR implementation to be top-down, yet still provide space for users to develop some control over the system. This brings up a secondary finding about informal documentation: we argue that informal documentation practices, in addition to serving several key work functions, also promote clinicians' control over local work systems. Informal documentation practices that emerged in both ED and L&D units allow clinicians to have more control over their documentation work, particularly for coordinating tasks. For example, when an ED doctor uses EMR to check lab results for a patient, she has to look at the list of all patients and go through each different lab result page. Doing so forces doctors to spend time going through several different results to locate the specific information they need. Unlike the formal EMR documentation practices, informal documentation made it possible for doctors to control how and when they would complete documentation work and to maintain their local coordination by requiring less rigid procedures or protocols.

Although retaining flexibility in documentation may be contrary to hospital procedures of governing the documentation of work, this flexibility means doctors can be actively involved and have more control over what happens in the patient care process, which is one of the main goals of patient care. Therefore, EMR systems should have the ability to be locally controlled and should respect local users' needs, activities, and work processes.

Re-thinking and Supporting Informal Documentation

Although creating a "paperless" system was a goal of EMR implementation in general, we found that clinicians in both the ED and L&D departments continued to use paper-based informal documentation practices (e.g., blank papers, printouts from the system). This finding is consistent with past research on "paper persistence" in hospital work systems. However, we assert that paper persistence is

evidence of the crucial function of informal documentation, which is often performed using paper artifacts. Our findings suggest that rather than problematizing paper persistence or accepting it as inevitable, we should focus on the function of informal documentation and find artifacts that afford this practice.

At present, the EMR does not provide tools that clinicians can use to develop artifacts for informal documentation, such as the L&D nurses' worksheet. The worksheet, in turn, indicates a lack of capability for the EMR to support short-term information use (the type of information usually recorded on paper working documents), which facilitates complex patient care work [9, 20]. The EMR system's current design largely leaves it up to the individual clinician to decide if and how to record this temporal and transient yet critical information. Thus, clinicians have found that personal notes compensate for the inadequacies of EMR design. Moreover, the use of personal notes reflects clinicians' fundamental work practices and leads us to reconsider the goal of EMR systems. Should EMRs be designed to store permanent records only, or should it also be used as a site to mediate the actual work practices in each individual department?

Most policy makers accept the usefulness of EMR systems given that they serve crucial administrative functions, principle among them being the reduction of the hospital's liability for medical personnel who fail to follow best practices, evidence-based care trajectories, standardizing workflows, or other administrative requirements. However, the system's design misses some important functions of the day-to-day practice of medical care, as we have shown. For this reason, the underlying conflict resides in the contradiction between the *exclusively formal documentation* in the EMR, which is characterized by archiving information for later auditing, and *short-term informal documentation*, which supports the temporal and emergent needs of practice. Therefore, we assert that the presence of paper is not an adequate measure of the success of an EMR. Instead, EMR designs should successfully support the transitory functions of informal documentation, not simply support its material medium of paper.

DESIGN OPPORTUNITES

Through the analysis of the ED and L&D documentation practices after EMR deployment, our study demonstrates that informal documentation is not a troublesome vestige of old paper-based systems but rather an essential component of medical work. We find that the tools provided by the EMR often leave gaps that can only be filled by informal documentation practices as these practices have developed and spread into wide usage in each unit. Informal documentation practices take slightly different forms in the two units but bear surprising similarities, indicating that hospital workers use informal documentation to fill several universal needs, regardless of the department in which work is occurring. Furthermore, EMR implementation can

exacerbate, rather than ameliorate, the need for informal documentation by creating new needs for memory, abstraction, and future work.

Currently, EMR systems are designed primarily with formal documentation in mind. We suggest EMR designers should consider and design for informal documentation practices through either digital or paper-based artifacts. Moreover, the design of informal documentation artifacts must afford flexible localization. For example, the EMR could give clinicians the ability to create customizable documentation artifacts to support their needs for abstraction and trajectory work in each unique unit. Each clinician could easily generate their own form of informal documentation media with whatever information they need to suit the needs of both system and management levels.

On the system-level, for example, ED doctors could create tailored, individualized forms that include only abstracted information they need, such as each patient's bed number, age, chief complaints, and key lab results. Alternatively, they could integrate tasks across multiple patients into a single timeline on the form. Just as with a doctor's personal notes, such forms could be printed and carried around. By collecting and organizing key pieces of information as needed throughout the care process, ED doctors could better oversee patients' progress and outline their future care trajectory. These artifacts would be created and used at the discretion of each individual. Thus, providing affordances for informal documentation artifacts in system design would allow local departments and individual users with different roles to customize the universal infrastructure to their own work practices.

At the management-level, managers and administrators should be aware that informal documentation is important to successful work practice and that informal documentation practices may be altered during or after EMR implementation. Managers should find ways to support informal documentation in clinicians' work. For instance, administrators should accommodate informal practices that are essential and universal to every local department. It is also necessary to acknowledge the different needs among administrators and clinicians, and to make those needs evident to each other, such as through forming workgroups. In addition, managers and administrators should recognize the need for a support local infrastructure, such as the need for medical workers to have customizable paper artifacts that are discarded and not maintained as part of the archived medical record. For example, they could examine personal note usage in ED doctors' work and make suggestions to use a better format (e.g. triage copies as personal notes) to better support their documenting process, so that doctors can use the basic information directly off triage copies without spending time writing this information onto their own notes every time.

Additionally, digital mobile artifacts could be developed to mediate various informal documentation practices.

Although the use of mobile technologies has been widely noted in facilitating health practices, these technologies need to provide affordances that are not available in existing mobile technologies. Our findings suggest that simply installing EMR systems on mobile platforms may not rule out paper usages, because what led to the use of paper notes, as we have discovered in our study, are not merely for being mobile. Instead, it is largely because the EMR design does not support informal documentation practices or afford informal documentation to the same degree that paper artifacts do, and that leads to the continuing use of paper. Digital artifacts to support informal documentation practice must provide the same affordances that paper-based artifacts do, including malleability, portability, and accessibility, and above all *delete-ability*. These characteristics promote successful informal documentation practices described above, and allow these practices to meet the demands of the specific contexts in which they are deployed. The attribute of delete-ability is echoed in prior design implications that concerned loss of hidden and psycho-social information emerged from the use of a formal system [16, 38]. It is worth mentioning that there may be political barriers to successfully implementing such artifacts. Increased oversight and precise specification of work practices are a hallmark of medical organizations at present [36]. Supporting informal documentation would require a recognition that in order for work to be effectively coordinated, some parts of the medical record may need to remain invisible to the eye of the organization. Thus, digital mobile artifacts must be designed for clinicians' working-in-use and not serve a second function as an artifact-for-accountability.

CONCLUSION

Through our analysis of informal documentation practices in ED and L&D after EMR deployment, we assert that informal documentation practices arise in response to universal needs for conducting memory, abstraction, and future work in heterogeneous healthcare contexts. Further, although informal documentation practice exhibits many stable characteristics, these practices take different forms depending on the local work processes, requirements, and resources present in each unique department. Informal documentation practices are an undervalued yet crucial part of hospital work systems and also a key site at which local users are able to take a measure of control of formal documentation work systems and adapt a hospital-wide infrastructure to local systems of work. Successful deployment of EMR across a healthcare organization requires designers to pay attention to support the crucial functions of informal documentation practices that allow clinical users to conduct memory, abstraction, and future work.

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