

# Chart biopsy: an emerging medical practice enabled by electronic health records and its impacts on emergency department–inpatient admission handoffs

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## ABSTRACT

**Objective** To examine how clinicians on the receiving end of admission handoffs use electronic health records (EHRs) in preparation for those handoffs and to identify the kinds of impacts such usage may have.

**Materials and methods** This analysis is part of a two-year ethnographic study of emergency department (ED) to internal medicine admission handoffs at a tertiary teaching and referral hospital. Qualitative data were gathered and analyzed iteratively, following a grounded theory methodology. Data collection methods included semi-structured interviews (N = 48), observations (349 hours), and recording of handoff conversations (N = 48). Data analyses involved coding, memo writing, and member checking.

**Results** The use of EHRs has enabled an emerging practice that we refer to as pre-handoff “chart biopsy”: the activity of selectively examining portions of a patient’s health record to gather specific data or information about that patient or to get a broader sense of the patient and the care that patient has received. Three functions of chart biopsy are identified: getting an overview of the patient; preparing for handoff and subsequent care; and defending against potential biases. Chart biopsies appear to impact important clinical and organizational processes. Among these are the nature and quality of handoff interactions, and the quality of care, including the appropriateness of dispositioning of patients.

**Conclusions** Chart biopsy has the potential to enrich collaboration and to enable the hospital to act safely, efficiently, and effectively. Implications for handoff research and for the design and evaluation of EHRs are also discussed.

## INTRODUCTION

Health information technology (HIT) has been widely viewed as holding great promise for bridging the quality chasm of the US healthcare system and for bending the curve of ever-rising costs.<sup>1–2</sup> Although evidence is not yet conclusive,<sup>3</sup> studies are beginning to demonstrate the anticipated value of HIT.<sup>4–6</sup> Additionally, the increased availability of data generated from widespread use of electronic health records (EHRs) is enabling transformative changes in the US healthcare system, including pay-for-performance, patient-centered medical home models, disease surveillance, and clinical, translational, and health services research.<sup>7–9</sup>

The majority of existing evaluation studies, however, have focused on linking HIT adoption to

outcomes, wherein ‘adoption’ is often defined as a healthcare facility ‘having’ an HIT system (or not) and ‘outcomes’ are usually measured according to a narrowly defined set of productivity or quality indicators.<sup>5–12</sup> While this approach is extremely valuable, it is often inadequate for pinpointing which processes, altered by the use of HIT, are actually responsible for the impacts observed. Consequently, the ability of these studies to inform future work on addressing deficiencies or replicating successes is limited. Furthermore, HIT use may contribute to many subtle changes in clinical work and clinician perceptions, the effects of which can be difficult to quantify or may not directly manifest through outcomes-driven analyses.

In this paper, we identify and describe an emerging, EHR-enabled practice, which we call ‘chart biopsy’, and which we define as ‘the activity of examining a patient’s health record to orient oneself to the patient and the care that patient has received in order to inform subsequent conversations about or care of the patient’. Drawing on data from a 2-year ethnographic study, we demonstrate how the use of an inpatient EHR system empowers general medicine physicians—who are on the receiving end during emergency department (ED) to general medicine admissions—to be better informed about patient cases and thus better positioned in handoff conversations. Our immediate objective is to identify the types of impacts that such usage may have on admission handoff, an important clinical process deserving a closer look in its own right. Our broader objective is to demonstrate how the unprecedented availability and accessibility of electronic patient care data, enabled through the use of EHRs, help to break information monopoly and engender new possibilities of information use and reuse in healthcare settings. These changes introduced by the use of EHRs have the potential to make clinical practice safer, more efficient, and more effective. Implications for handoff research and for the design and evaluation of EHR systems are also discussed.

## BACKGROUND AND SIGNIFICANCE

In complex healthcare systems with highly specialized divisions of labor, transitions in care are inevitable but come with significant potential risks to safety and quality of care.<sup>13–14</sup> Patient handoffs are the communication activities meant to coordinate these transitions through the transfer of information, responsibility, and control.<sup>15</sup> However,

concerns that handoffs often fail to adequately coordinate such transitions have prompted a movement to improve patient handoff processes.<sup>16</sup>

Although some acknowledge that handoffs often require interaction,<sup>17–18</sup> including the opportunity for the receiving party to ask questions,<sup>13–19</sup> much of the handoff research to date has implicitly adopted a conceptual model of handoff as a largely one-way information transfer activity in which the party handing off has a virtual monopoly on information.<sup>20–21</sup> This conceptual view, in turn, has shaped approaches to measurement and improvement. For instance, efforts to standardize handoffs have focused on structuring the information provided by the party handing off.<sup>22–25</sup> Similarly, efforts to evaluate handoffs have measured the completeness,<sup>22–26–31</sup> and accuracy<sup>27–29–32</sup> of information transferred, and the retention of information by the receiving party.<sup>23–33–34</sup> While these various efforts have made important contributions, they have either overlooked the role of the receiving party or else positioned that party as a passive recipient of information, whose primary active role is to ask questions for clarification or to confirm information transferred through read-back techniques.<sup>35</sup>

This conceptual view of handoff as an information transfer activity also overlooks the potential of EHRs to influence the formation of knowledge on the part of the *receiving* party. The available studies that have explored how EHRs can be used to support handoffs generally show that the quality of transitions can be improved when EHR data are used to populate handoff documents automatically,<sup>36–39</sup> sometimes with the side benefit of reducing redundant data entry.<sup>40</sup> To our knowledge, however, few studies have explored how EHRs are used by parties on the receiving end of handoffs *before* entering handoff conversations and how this practice may affect the subsequent handoff interaction.

One transition where we might expect to see intensive EHR use by receiving parties prior to handoff is during admissions when patients are transitioned from an ED to an inpatient unit. Communication during such handoffs can be particularly challenging because: (1) parties involved tend to come from different medical specializations with distinct perspectives on and approaches to illness and treatment; and (2) patients passing through EDs tend to be at particularly vulnerable points in the trajectories of their illness episodes.<sup>41–42</sup> These factors can lead to disagreements over diagnoses, different opinions regarding disposition, and the need to negotiate during admission handoffs.<sup>43–45</sup> Thus, given the challenging nature of communication and interaction in ED–inpatient admission handoffs, clinicians on the receiving end would have a strong incentive to make full use of EHR data prior to handoff.

## MATERIALS AND METHODS

To address the gap in the literature, we draw from a 2-year, field-based qualitative investigation and examine the role that EHRs play in admission handoffs between the ED and general medicine services. Field-based qualitative research is particularly useful for describing and understanding how technologies are actually used in practice and how that use interacts with other work processes and organizational structures.<sup>46</sup> Such approaches have been commonly used in health informatics research and have yielded valuable insights.<sup>47–49</sup>

In this study, we used a grounded theory methodology,<sup>50–51</sup> an inductive approach in which data were collected and analyzed in an ongoing, iterative process. As data were gathered,

they were analyzed, and the emerging analysis was used to direct subsequent data collection efforts. For the sake of simplicity, we describe our data collection and data analysis in separate subsections below.

## Study site and study participants

All data were gathered at the University of Michigan Health System (UMHS), a highly specialized tertiary teaching and referral hospital. Each year, more than 1.6 million outpatient and emergency visits, 45 000 hospital stays, 61 000 surgeries, and 4000 births take place at facilities operated by UMHS hospitals and health centers. A web-based institutional EHR system, called CareWeb, has been used at UMHS since 1998. CareWeb contains clinician notes, laboratory test results, radiographic images, and other basic patient information from both inpatient stays and outpatient visits. In addition, the system contains records pertaining to a patient's ED stay, such as nurse triage notes, admission requests, and a time-stamped list of activities undertaken in the ED.

At UMHS, patients may be admitted through the ED to different inpatient services, including general internal medicine, cardiology, hematology and oncology, gastroenterology, and general surgery, among others. In our field investigations, we focused primarily on three adult care units: the ED, the general medicine residency service, and the general medicine hospitalist service. The general medicine services were selected because they receive the largest volume of admissions from the ED.

Data collection involved theoretical sampling to identify prospective study participants. Theoretical sampling is a purposive sampling approach commonly used in grounded theory in which participants are selected based on emerging analyses.<sup>50–51</sup> Findings reported in this paper are drawn from data obtained from a total of 73 physicians and surgeons. Of these, 40 were emergency medicine physicians (13 attendings and 27 residents), 28 were internal medicine physicians (17 attendings, 10 residents, and one fellow), and five were surgeons (one attending and four residents). In this paper we focus on how inpatient physicians use EHRs to prepare for admission handoffs; therefore, most of the data we report are taken from interviews and observations with internal medicine physicians.

Some participants were recruited through general email announcements sent out periodically during the course of the study. Others we recruited at the suggestion of previous participants. Still others volunteered when they learned about the study by word-of-mouth; all volunteers were accepted for participation.

## Data collection

We triangulated our data collection in order to ensure a richly contextual and holistic dataset and to improve the trustworthiness<sup>46–52</sup> of the study. Our multiple data collection methods included semi-structured interviews, observations, and recorded handoff conversations. The first author gathered all data between January 2009 and March 2011. Informed consent was obtained from all participants prior to data collection. The identities of participants and patients were removed from all transcripts and field notes before analyses.

Semi-structured interviews (N=48) each lasted about 1 h and were used to gather participants' perceptions about admission handoff practices and challenges encountered. The exact topics covered in the interviews varied over the course of the study

based on the emerging analyses. All interviews were digitally recorded and transcribed verbatim.

A total of 349 h of observations were conducted over the 2-year study period: 146 h in the ED, 108 h on the hospitalist service, and 95 h on the general medicine residency service. The first author shadowed 46 physicians and interacted with numerous others; however, he did not directly participate in clinical activities. Observations varied from 1 h to 8.5 h in length, with an average of 5 h. Our observation data resulted in more than 220 typed, single-spaced pages of field notes.

Between November 2009 and June 2010, we recorded a total of 48 telephone handoff conversations between ED physicians and general medicine hospitalists and residents. A trained medical transcriptionist then transcribed these conversations, yielding approximately 48 pages of single-spaced text.

**Data analysis**

Coding followed an inductive approach, by which themes were allowed to emerge rather than being imposed on the data.<sup>50</sup> Initial analyses involved in vivo coding<sup>53</sup> to preserve our participants' terms and perspectives, as well as process coding<sup>50 53</sup> to focus analyses on actions. During subsequent rounds of coding, we consolidated related codes into broader themes, including the central one discussed in this paper: 'doing a chart biopsy'. Memos written throughout the analysis process captured ideas and emerging insights into the codes and were useful for constant comparison,<sup>51</sup> making connections between codes and among data.

Consistent with ethnographic approaches, we used member checking<sup>54</sup> to validate and further refine our research findings. Early reports of this study were shared individually with five participants (3 ED and 2 General Medicine physicians), who were selected because they were particularly interested in and articulate about the issues under study. Their feedback provided additional data and helped clarify and sharpen the analysis.

**RESULTS**

In this section, we present our results organized around our two main objectives: (1) to examine how physicians on the receiving end of admission handoffs use EHRs in preparation for those handoffs; and (2) to identify the kinds of impacts that such usage may have. For the first objective, we describe an EHR-enabled, emerging practice referred to as *chart biopsy*. For the second objective, we report both the perceptions of our participants and our own observations of how this practice is influencing handoff interactions and the quality of admissions work.

**Chart biopsy: an emerging practice**

At UMHS, once an ED physician has decided to admit a particular patient, that physician must send an alphanumeric page to the inpatient physician who is accepting admissions for the service to which the patient is expected to be admitted. The inpatient physician then calls the ED physician, and the handoff occurs over the telephone. Our analysis reveals that the EHR enables a new step in this process, pre-handoff chart biopsy, often taken by the receiving physician between the time the ED physician sends the page and the time that the inpatient physician calls back to take the handoff.

Chart biopsy is an in vivo term used by some of our study participants. Just as the medical procedure of biopsy involves the targeted selection, retrieval, and examination of bodily tissue to aid in the process of diagnosis, so a chart biopsy involves the targeted selection of information and data from

patient records to aid the clinician in the process of learning about the patient in order to inform subsequent conversations about or care of that patient. Clinicians may perform chart biopsies at any point in a patient's care trajectory; however, in this paper we focus on chart biopsies performed by inpatient physicians prior to taking admission handoffs.

The practice of chart biopsy appears to be highly variable. None of our participants reported being aware of any protocols for conducting chart biopsies, nor had any of them ever received formal training in the activity. However, similar to previous studies on clinical documentation,<sup>55-57</sup> we observed clinicians informally sharing with one another advice on how to find various kinds of information within the EHR to facilitate the chart biopsy process. Not surprisingly then, the practice varied considerably from one clinician to the next, and in some cases even the same clinician conducted chart biopsies differently from one instance to the next. Here we describe some of the actions we observed repeatedly, but also make note of certain variations in behavior to provide a more complete picture of clinicians' chart biopsy activities.

**Functions of chart biopsy**

As summarized in table 1, chart biopsy serves at least three functions: (1) getting an overview of the patient, (2) preparing for handoff and subsequent care, and (3) defending against potential biases. First, because time constraints typically prevent extensive reading, pre-handoff chart biopsy usually involves getting a general overview of the patient rather than a thorough understanding. Often, even cursory encounters with the record can produce influential impressions. For example, simply by seeing the number of entries in the record or the types of clinicians that have provided care to the patient in the past, the inpatient physicians began forming impressions of how 'sick' the patient was and the kinds of care that might be needed. In some cases, the inpatient physicians developed expectations of patients without reading a single note in the record. In one example, seeing a note in the record from an institution he recognized, one hospitalist proclaimed: 'She's going to be sick: she's in a nursing home'.

**Table 1** Functions of chart biopsy

Function	Representative quotations
Getting an overview of the patient	<ul style="list-style-type: none"> <li>▶ <i>It just gives you kind of an overall gist of the patient, of how likely—I guess it just helps put them on the continuum of sick versus not sick, which is kind of what you first develop or your reaction</i></li> <li>▶ Field note excerpt: <i>[The participant] sees recent notes from a physician she recognizes by name and knows to be an oncologist, so she presumes the patient has cancer</i></li> </ul>
Preparing for handoff and subsequent care	<ul style="list-style-type: none"> <li>▶ <i>I'm also thinking, 'What are they going to need when they go home?' I have to have those questions in mind right from the get-go, even when I'm admitting, even sometimes at the point of the chart biopsy, so that I can anticipate their care</i></li> <li>▶ Field note excerpt: <i>[The participant] tells me he is forming a differential diagnosis. Things he will be listening for in the handoff in hopes of confirming or ruling out</i></li> </ul>
Defending against potential biases	<ul style="list-style-type: none"> <li>▶ <i>It's like buying a car. You don't just take the dealer's word</i></li> <li>▶ <i>I just do what we call the chart biopsy real quick, and then I call back and get the story. Because again, ... what they think is going on might not be accurate</i></li> </ul>

Getting an overview of the patient's case often involves getting a sense of the patient's illness trajectory and understanding where the patient currently is in that trajectory. But illness trajectories are not always visible in individual data points. Rather, the inpatient physician must look for patterns across data and over time. Thus, in seeking an overview of patient cases, physicians often looked at results of the same diagnostic test gathered at different points in time. Typically, this involved switching between documents/records stored in the EHR, or opening multiple windows and switching between them. One resident expressed the desire to be able to look at such data from different visits side by side for easy comparison.

Second, chart biopsy is a preparatory activity: it prepares inpatient physicians for handoff, for anticipating patient needs, and for fulfilling documentation requirements. Our study participants referred to chart biopsy as doing 'my homework' and 'my due diligence', which lays a foundational understanding on which information shared during the handoff can be built. Chart biopsy also prepares inpatient physicians to assume responsibility and begin planning care. During chart biopsy, inpatient physicians often began thinking about additional diagnostics, medications, and therapies they might order and any other services that might need to be involved, such as social work or sub-specialty care. By anticipating these needs during chart biopsy, inpatient physicians on the receiving end of admission handoffs felt they were better prepared to assume responsibility and move care forward quickly and safely during transitions. Finally, chart biopsy also prepares inpatient physicians for documentation tasks by providing an initial orientation to the patient's past medical history, which may later be used in the admission note.

Third, chart biopsy can act as a defense mechanism to reexamine the ED physician's understanding of the patient and to guard against potential cognitive biases, such as diagnosis momentum (ie, 'the tendency for a particular diagnosis to become established without adequate evidence'<sup>58</sup>). Rather than simply accepting patients as presented in handoffs, inpatient physicians used chart biopsies as opportunities to develop their own understandings of patients and to analyze the appropriateness of admitting those patients and placing them on their services. For example, in an interview, a hospitalist recalled how a pre-handoff chart biopsy had been instrumental in avoiding an unnecessary admission: having received a page from the ED about a patient being admitted for meningitis, the hospitalist examined the patient's laboratory test data during chart biopsy and found a positive result for strep throat. In the subsequent handoff, she used this information to engage the ED physician in a re-examination of the case. Together they concluded that the diagnosis was strep throat and that an admission was not necessary. The hospitalist explained that they 'discharged [the patient] home with amoxicillin, but that was originally going to be an admission for meningitis'.

### A situated process

We also found that chart biopsy is a *situated* process, that is, the steps taken appear to vary depending on several situational aspects and the understanding of the patient that unfolds as the clinician conducts the chart biopsy. In this section, we describe five of these aspects, namely: (1) notification technology and practices, (2) past experiences, (3) information encountered in the chart, (4) other work demands, and (5) the EHR system. We also demonstrate how these aspects situate the process of chart biopsy. Table 2 provides a summary.

First, chart biopsy is dependent in part on the practices and technology (ie, alphanumeric paging system) used to notify the inpatient physician of an upcoming admission. When the page provides the patient's identifier along with other information about the patient, such as the admission diagnosis, chief complaint, or even the patient's age, this additional information has the effect of framing the patient and thereby suggesting where to look in the record. For example, as one hospitalist explained, 'If it's a patient with heart failure, I'll look for their last echocardiogram to see what their heart function is like'. One hospitalist referred to this as 'targeted searching', in which attention is focused on particular parts of the record in search of specific information relevant to the physician's present concerns. On the other hand, when the page provides no patient identifier, the physician on the receiving end is not able to locate the appropriate record in the EHR and, therefore, cannot conduct a chart biopsy at all.

Second, past experiences also situate the chart biopsy process and influence inpatient physicians' thinking. For example, some participants pointed to previous experiences in which they had accepted handoffs from the ED, only subsequently to learn details that suggested the patient did not require admission or would have been better served on another service. Such experiences guide the information seeking of chart biopsy and focus attention on certain common concerns in the cases of patients with particular presenting conditions. These concerns often relate to two triage questions: (1) is the admission necessary?

**Table 2** Aspects that situate the process of chart biopsy

Aspect	How	Representative quotations
Notification technology and practices	Frames patient through description, diagnosis, chief complaint information, etc.	<i>If a patient is being admitted for something that is related to a cancer, then I'll look at the last note from their oncologist, because that will let me know where is their cancer at right now</i>
Past experiences	Attune the receiving physician to certain common concerns in the case of patients with particular presenting conditions	<i>I look them up, look for certain criteria, make sure their stability makes sense for the floor as opposed to the ICU, because sometimes that's not always been reviewed</i>
Information encountered in the chart	Alerts clinician to issues not mentioned in the alphanumeric admission page and triggers further information seeking both within the chart and with ED physicians during the subsequent handoff conversation	Field note excerpt: <i>[The participant] looks up the patient in CareWeb. She sees that amylase lipase labs were ordered in the ED. From this, she knows [the admission] will be 'abdominal pain'</i>
Other work demands	Constrain the time spent in the chart and the extent to which the record is examined	<i>Well by now I do have a system [for chart biopsy], unless, let's say I'm swamped, and I'm in seeing a patient, and ER keeps paging me, paging me, paging me. I step out and just call without even looking up</i>
EHR design (including functionality and usability)	Enables or limits clinician's ability to see the big picture	Field note excerpt: <i>[The participant] wants an easy way to view labs from previous visits side by side with current labs. He has to switch back and forth between windows to compare numbers</i>

ED, emergency department; EHR, electronic health record; ER, emergency room; ICU, intensive care unit.

and (2) is the chosen service the most appropriate unit to provide the anticipated care? It should be noted that although this situating by past experiences may provide benefit in some cases, it also has the potential to bias inpatient physicians' thinking in favor of most recent cases.<sup>58 59</sup>

Third, the chart biopsy process itself is dynamic, with later phases depending crucially on earlier ones. As a result of details noticed in the chart, inpatient physicians sometimes developed concerns about the care of the patient or the disposition plan. These concerns, in turn, triggered further information seeking both within the chart and with the ED physician during the subsequent handoff conversation.

Fourth, other work demands constrain chart biopsy. The amount of time spent and the extent of the record examined vary in part depending on the demands placed on the receiving physician's time and attention by co-workers and by other responsibilities. Feeling pressured to call the ED immediately for handoff often resulted in inpatient physicians cutting short or even forgoing chart biopsy altogether in some instances.

Finally, EHR design also affects inpatient physicians' ability to piece together data and see the bigger picture. For example, to understand the trajectory of a patient's illness, participants often looked at results of the same diagnostic gathered at different points in time. However, because the EHR system provided no convenient means for conducting this comparison, they had to go backward and forward between documents/records or open multiple windows and switch between them. Furthermore, because EHR systems may not always contain an up-to-the-minute record of all information and descriptors about the patient, but only an evolving account, physicians may gain a different understanding of the patient depending on when they access the system relative to when information is entered. As a result, sometimes the overviews obtained from pre-handoff chart biopsy could be incomplete, out-of-date, or even inaccurate. Typically these misunderstandings had to be worked out during handoff conversations.

### Impacts of chart biopsy

Chart biopsies appear to impact important clinical processes and outcomes. Among these are the nature and quality of handoff interactions, and the quality of care, including the positioning of patients.

Pre-handoff chart biopsy may enrich the quality of the handoff itself. The understanding constructed during a chart biopsy enables the inpatient physician to listen, think, and interact more critically during the handoff, including asking more meaningful questions and proposing alternative understandings of the patient's case. As a result, inpatient physicians in our study reported feeling less 'at the mercy' of ED physicians for information and understandings of patients. Furthermore, by conducting a pre-handoff chart biopsy, they felt that they were guarding against negative aspects of poor handoffs, including the omission of important information, the inclusion of distracting details, and 'disorganized ramblings'. As partial evidence of these positive impacts, our study participants pointed to instances when they had failed to do pre-handoff chart biopsies as well as to their prior experiences in hospitals that lacked EHRs. For example, in the words of one hospitalist, handoffs at the institution where he formerly practiced would 'bumble down the road' in part because inpatient physicians at the receiving end would have to enter the handoff situation knowing nothing about the patient.

Therefore, conducting chart biopsies may directly influence disposition decisions. Some participants reported that as a

result of doing a chart biopsy they were better able to avoid unnecessary admissions or inappropriate placement of patients. They argued that chart biopsy enabled them to present an alternative interpretation of some patients' conditions and thus to advocate alternative disposition plans. Regardless of whether or not a pre-handoff chart biopsy was conducted, many of the admission handoffs we observed exhibited the qualities of a negotiation in which the handoff parties argued for or against particular admission and placement decisions. While a complete examination of the processes and the outcomes of such negotiations is beyond the scope of this paper (see<sup>43 45</sup>), our analyses illustrate that EHR-enabled pre-handoff chart biopsy has emerged as a key practice redefining these negotiations. As we observed, sometimes chart biopsy enabled the inpatient physician to argue more persuasively, and sometimes it reduced the need for negotiations altogether, as when the information gained from chart biopsy reinforced what the ED physician subsequently presented during the admission handoff.

### DISCUSSION

The widespread adoption of EHRs has significantly improved the availability and accessibility of patient care data, thereby creating new possibilities for information use and reuse that may have the potential to improve the quality, safety, and efficiency of clinical work. Documenting and assessing subtle changes to work processes and information flows introduced by EHR use is an important part of the ongoing work of evaluating the impacts of such systems—many of which may be difficult to quantify—in order to understand end-user behaviors and to harness the full value of EHRs. The analyses reported in this paper represent a step in that direction. Our qualitative study of admissions work at a large tertiary hospital identifies the newly emerging practice of chart biopsy, traces its effects on admission handoffs between ED and general medicine physicians, and provides an illustrative example of EHRs' transformative effects on patterns of coordination, communication, and decision-making in complex healthcare systems.

### The value of chart biopsy

We found that as a result of doing a chart biopsy prior to handoff, parties on the receiving end were better positioned to propose and explore alternative understandings of patients and different approaches to care during handoff conversations. Chart biopsy can enrich coordination and collaboration, improving the hospital's ability to act safely, efficiently, and effectively. If handoff is an opportunity for the receiving party to provide a fresh perspective and to catch errors, as others have observed,<sup>60-62</sup> then the practice of chart biopsy has the potential to equip receiving parties to better seize this opportunity. However, in this study, we also observed considerable variety in the practice, including inpatient physicians forgoing chart biopsy altogether when other work demands intervened. Likewise the organic, emerging nature of the chart biopsy practice means that clinicians are left to develop their own individual processes. These findings imply that hospitals may not have realized the full potential of chart biopsy, and hence the full value of EHRs. Further research is needed to identify best practices to develop programs for training clinicians to perform chart biopsies more effectively and efficiently, and to guide the design of facilitating conditions and supporting technologies. Similarly, cultural changes may be needed to emphasize the importance of chart biopsy, and work process changes may be required to ensure adequate opportunities for clinicians to engage regularly in the chart biopsy practice.

Nevertheless, this is not to suggest that the consequences of chart biopsy are always beneficial. As we noted earlier, the quality of the understanding constructed during chart biopsy is partially contingent on the quality and completeness of the information contained in the record, which in turn can be partially contingent on the interoperability of electronic systems<sup>63 64</sup> and clinicians' documentation practices.<sup>55 65</sup> To the extent that clinicians conducting chart biopsies develop superficial or inaccurate impressions of the patient or of the care the patient has received, the resulting negotiations during handoff may be inefficient and produce misunderstandings or even animosities. Furthermore, if—as some of our participants suggested—work avoidance motivates certain negotiations in admission handoffs, then chart biopsy may enable avoidance of more work to the extent that it better equips the receiving clinician to argue against the disposition. While we believe the practice of chart biopsy holds considerable promise to enrich collaboration between providers and thereby to improve quality of care, these negative aspects of chart biopsy underscore the need for further examination of the practice so that both EHRs and organizational structures can be better designed to support it, and so that clinicians can be appropriately trained to do it well.

### The role of EHRs in facilitating chart biopsies

As illustrated in this study, EHRs open up new possibilities of information reuse by enabling more convenient access to more diverse information prior to handoff or other activities. None of the chart biopsies reported in this paper would have been possible in a paper-based operation, as records would have been scattered across a variety of physical locations, inaccessible in the brief time available prior to handoff. In many respects then, the practice we have documented is an emerging phenomenon. As EHRs proliferate, we can expect to see more of such practices and their effects on clinical work processes and outcomes. For example, our observations also suggest that chart biopsies are increasingly being conducted by attending physicians before daily rounds or before rotating onto a service, and that nurses have begun to conduct chart biopsies to inform themselves of the actions of physicians and other types of healthcare professionals. Such chart biopsy activities will likely change the distribution of information and shape understandings of patients, thereby altering many clinical routines from daily rounds to discharges, with potential impacts on patients and the organization.

Importantly, however, it is not the EHR system itself that alters clinical work processes and impacts safety, quality, and efficiency. Rather, it is the practices that emerge and are reinforced as the technology is used that produce such transformative changes.<sup>66 67</sup> To fully understand both the potential and the actual impact of EHRs on important outcomes, additional research is needed to examine how EHRs are enacted through use and how this use evolves over time. Our study provides one such examination.

### Implications for handoff improvement and EHR redesign

Our findings also have implications for the conceptual models and assumptions that largely dominate handoff research and practical efforts to improve patient handoffs. Even when parties on the receiving end of a handoff may not have previously cared for the patient, the information they gather from chart biopsy can help to shape their thinking about the patient and set in motion their evaluation of the disposition plan prior to handoff. As a result, these clinicians enter handoff not as

passive recipients of information, but rather as active co-constructors of an understanding of the patient and as active participants in the planning of care. Handoff evaluation and improvement efforts that overlook this reality and assume handoff is a one-way transmission of information may miss crucial details and valuable opportunities.

We must, therefore, alter our conceptual model of handoff to account for interaction, co-construction of understanding, and the active participation of the parties receiving responsibility.<sup>21</sup> This means that research and improvement efforts need to recognize the unique dynamics of those handoffs in which receiving parties have some prior understanding of the patient or some adequate means to obtain that understanding (eg, through EHR-enabled chart biopsy). It also means that more attention should be paid to the impact of the questions and contributions to the handoff conversation made by the receiving party since these may shape not only the conversation itself but also the ongoing care of the patient. An expanded conceptual model accommodating such new forms of patient handoff engendered by the use of EHRs is therefore warranted. Furthermore, in order to develop handoff practices that realize the full potential of electronic patient care data, hospitals may need to enact larger cultural and process changes to foster a view of handoffs less as information transfer activities and more as exchanges of understandings and moments of active collaboration.<sup>45</sup>

In addition, accreditation bodies such as The Joint Commission, patient safety advocacy organizations such as the Institute for Health Care Improvement, and funding agencies such as the Agency for Healthcare Research and Quality have already shown interest in driving handoff improvement through licensure requirements, standards, and toolkits. The expanded conceptual model of handoff proposed in this paper may provide valuable insights into the ongoing work of defining, guiding, and supporting new handoff practices in the emerging digital era. Similarly, this model implies that faculty who are developing handoff training curricula<sup>17</sup> to comply with the Accreditation Council for Graduate Medical Education requirements for improved continuity of care<sup>68</sup> may want to incorporate collaboration into their training and evaluation metrics. The findings also suggest that such training programs can benefit greatly from including instruction on the use of EHRs to better support the collaborative and increasingly data-driven nature of patient care.

The findings of this study also have implications for EHR redesign. For example, information fragmentation, a common issue in current EHR design,<sup>64 69</sup> segments relevant patient care data into distinct functional areas (eg, diagnosis vs laboratory tests vs medications). Our field observations suggest that information fragmentation may hinder the chart biopsy process, as it necessitates significant navigation efforts in order to assemble data from discrete screens and documents in order to construct an understanding of the patient. Further, we found that our participants relied on skimming and scanning—as opposed to thorough reading—in order to quickly obtain a longitudinal overview of the patient case. This suggests opportunities to develop new functionalities, such as automated assembling of clinical data from across visits to produce graphical representations of the patient's illness trajectory over time<sup>70</sup> in order to improve the effectiveness and efficiency of chart biopsy activities. Similarly, future EHRs might provide more intelligent information retrieval algorithms to facilitate selective reviewing of specific clusters of patient care data (eg, all past tests and treatments related to a particular disease) that may be scattered

across clinician notes or across care episodes. They might also include the capability of highlighting potentially concerning divergences between visits.

### Limitations and strengths

Our study was conducted in a single institution and was focused on one particular clinical activity: admission handoff. It is reasonable to expect that the pre-handoff chart biopsy practice might work differently in other institutions where patient populations, clinician practice style, EHR and notification technologies, and hospital admission policies are different. Likewise, the practice may be different when performed in service to other clinical tasks or by other kinds of clinicians. Our qualitative approach provides one perspective on an emerging phenomenon.

Qualitative methods are particularly appropriate for understanding social actions in context, for discovering previously unexplored aspects of phenomena, and for pointing the way to new avenues of research. This paper makes several contributions, including describing the previously undocumented practice of chart biopsy; highlighting its effects on admission handoffs; providing an example of how EHR use is influencing the way care is coordinated; and tracing the potential impacts of such use on safety, quality, and efficiency.

### CONCLUSION

The potential of EHRs to improve quality and reduce costs, as well as the actual effects they have on outcomes, depend in part on how they are used. In this study we have examined the practice of pre-handoff chart biopsy and traced its effects on admission handoffs between ED and general medicine physicians. In so doing, we have documented an example of how the increased availability and accessibility of patient care data made possible by EHRs are changing clinical work processes and impacting quality, safety, and efficiency.

By altering the availability and accessibility of patient information, EHRs make it possible for inpatient physicians to form initial impressions of patients prior to taking handoff from the ED. Consequently, inpatient physicians enter admission handoffs not as passive recipients of information, but rather as active participants engaged not only in the transfer of information, but also in the co-construction of that information into an improved understanding of the patient and the planning of care.

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