Paper- and computer-based workarounds to electronic health record use at three benchmark institutions

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ABSTRACT

Background Healthcare professionals develop workarounds rather than using electronic health record (EHR) systems. Understanding the reasons for workarounds is important to facilitate user-centered design and alignment between work context and available health information technology tools.

Objective To examine both paper- and computer-based workarounds to the use of EHR systems in three benchmark institutions.

Methods Qualitative data were collected in 11 primary care outpatient clinics across three healthcare institutions. Data collection methods included direct observation and opportunistic questions. In total, 120 clinic staff and providers and 118 patients were observed. All data were analyzed using previously developed workaround categories and examined for potential new categories. Additionally, workarounds were coded as either paper- or computer-based.

Results Findings corresponded to 10 of 11 workaround categories identified in previous research. All 10 of these categories applied to paper-based workarounds; five categories also applied to computer-based workarounds. One new category, no correct path (eg, a desired option did not exist in the computer interface, precipitating a workaround), was identified for computer-based workarounds. The most consistent reasons for workarounds across the three institutions were efficiency, memory, and awareness.

Conclusions Consistent workarounds across institutions suggest common challenges in outpatient clinical settings and failures to accommodate these challenges in EHR design. An examination of workarounds provides insight into how providers adapt to limiting EHR systems. Part of the design process for computer interfaces should include user-centered methods particular to providers and healthcare settings to ensure uptake and usability.

INTRODUCTION

The Health Information Technology for Economic and Clinical Health (HITECH) Act, enacted in 2009, encourages widespread adoption of health information technology (health IT) to improve quality and coordination of care, and to reduce medical errors.[1] Health IT tools have the potential to improve work practices for many patient care processes.[2 3] However, the current health IT tools do not support all clinical work and, thus, users might perceive them as impediments to delivering efficient patient care. For example, difficulty in finding necessary patient data, complex order entry processes, and rigid algorithms for alerts are documented shortcomings in health IT systems.[4] Additionally, these tools can necessitate change to clinical work practices, such as modified timing and sequence of work practices and revised professional responsibilities.[5–7]

As a result, to avoid these impediments and complete the task at hand, providers and staff often develop workarounds.[8] Koppel *et al*[9] define workarounds as 'actions that do not follow explicit or implicit rules, assumptions, workflow regulations, or intentions of system designers. They are non-standard procedures typically used because of deficiencies in system or workflow design.' We use this as our operational definition for workaround by extending it to include real or *perceived* limitations in a technical system. Workarounds are manifested from a misalignment of the available health IT with personnel, work practices, and environment.[9] Consistent with the 'bad apple' fallacy of Karsh *et al*, workarounds are viewed as a system-level issue in this study, involving people, technology, context, and other organizational factors and interactions among these factors.[10] Following from this perspective, health IT users are not solely to blame for workarounds or non-compliance.

Workarounds include (1) mostly harmless actions that do not necessarily change work practices or affect data accuracy, (2) circumvention of health IT processes or procedures as a result of user interface flaws or human–technology integration factors, or (3) necessary actions to complete a task.[11] For example, in one study, a workaround solution for nurse coordinators in an inpatient setting included assembling critical information on a clipboard at the end of each shift to pass on to the incoming nurse coordinator. The information contained on the clipboard supported their work and was easily accessible (and a mobile information source). In this example, the electronic medical record was used less often than the information on the clipboard during a nursing shift.[12] This paper-based workaround is a distinct example of an alternative work process developed to promote efficiency and meet specific information and task requirements in a situation in which the available electronic tools did not support nursing work. Other examples of workarounds include over-riding safety alerts,[13] skipping barcode medication administration process steps,[9] and using paper forms in place of the electronic health record (EHR).[6]

Although workarounds may seem necessary to health IT users and are not always problematic, they can pose a threat to patient safety.[9 14] For example, workarounds used with barcoded medication administration systems to increase efficiency can result in giving medications to the wrong

patient or in wrong doses.[8 9] Also, workarounds have resulted in the time stamp for medication administration being incorrect,[15] which can affect the timing for subsequent medication.

Understanding workarounds is central to understanding where the health IT tool diverges from clinical work practices. This knowledge can inform redesign of health IT to support the varied clinical work practices of different providers (nurses, physicians, pharmacists) and patient care activities (eg, patient discharge, referral, laboratory monitoring). Thus, the objective of our study was to classify types of workarounds to EHR use. Specifically, the goal of the study was to identify non-standard ways that healthcare professionals use or circumvent the EHR to complete their work. Because workarounds depend on the context, we used direct observations to understand conditions and work processes surrounding workarounds. Other studies have used similar methods of direct observation to understand work in 'real-world' contexts.[5 9 15] Also, direct observation is advantageous compared to other methods (eg, interviews and focus groups) in studying phenomena, such as workarounds, since the data are based on what providers are seen doing, not on what providers say they do, which can often be different.[16]

This study is unique in conducting observations at three benchmark institutions. We chose to focus on benchmark institutions as these sites are likely to have deeper and broader experience with EHR systems than smaller institutions. We expect that lessons learnt from these organizations will be valuable to other health systems that have recently adapted EHRs or are planning to integrate an EHR in the near future. Existing publications primarily focus on workarounds to a specific process (eg, barcoded medication administration), but we focus on understanding broad categories of workarounds to the EHR in this study. Additionally, this study extends previous studies by examining the medium used (paper-based vs computer-based) for workarounds. This study extends our understanding of the categories of workarounds, reasons for workarounds, and implications for user-centered design.

METHODS

Study sites and participant characteristics

Qualitative data were collected in 11 primary care outpatient clinics across three healthcare organizations: Veterans Affairs (VA), Regenstrief Institute, and Partners HealthCare System. We included two VA medical centers which resulted in a total of four participating sites. Based on a recent review, these organizations can be considered benchmark institutions in health IT implementation and use since they are often cited for high-quality research demonstrating the efficacy of EHR in improving quality and efficiency.[17] The intent for the primary study was to observe best practices and identify barriers and facilitators to effective use of colorectal cancer (CRC) clinical decision support for the various modalities of CRC screening: fecal occult blood test, flexible sigmoidoscopy, and colonoscopy.[18] Observations were recorded broadly to capture as much of the surrounding context and richness of the work and were not limited to CRC-related work. Thus, general workarounds to EHR use were captured during observations.

For each site, observations were made over 2 days. The study participants were ambulatory care providers and staff. Each observer employed a maximum sampling strategy in which he/she stayed with one provider through an average of two EHR interactions before observing another provider. Criteria for participating in the study included employment as a healthcare worker in the ambulatory care clinics of the study sites. Patients were not specifically recruited. Rather, they were observed when their provider was actively participating in the study. Observations were made in three clinics at site 1, one clinic at site 2, four clinics at site 3, and three clinics at site 4. We observed a total of 120 healthcare workers across the four sites (see table 1).

Table 1 Number and clinical role of participants by study site

Clinical role	Study sites			
	Site 1 (East USA, VAMC)	Site 2 (Midwest USA)	Site 3 (South USA, VAMC)	Site 4 (East USA)
PCP				
Physician	6	10	11	15
PA	2	0	2	0
NP	1	0	6	2
RN/LPN	2	1	14	7
HT/MA	8	11	1	7
Front desk clerk	0	7	0	4
Other	0	1	1	1
Total	19	30	35	36

HT, health technician; LPN, licensed practical nurse; MA, medical assistant; NP, nurse practitioner; PA, physician assistant; PCP, primary care provider; RN, registered nurse; VAMC, Veterans Affairs medical centers.

The existing EHR systems across these benchmark institutions are variable. Additionally, the extent to which paper forms are sanctioned and part of typical work practices is also variable. For example, for preventive health screenings, both VA medical centers used computerized clinical reminders. In contrast, the Regenstrief Institute used paper reminders that were automatically generated by electronic decision support tools. Partners HealthCare included preventive health screenings as part of an electronic, template health maintenance list. Detailed descriptions of each institution's EHR system have been published.[19–24]

Field study methods

Researchers used direct observation to understand the range of ways in which providers interact with, and use, EHRs in real time. To collect data using direct observation, we employed rapid ethnographic methods rather than a traditional ethnographic approach. A traditional ethnographic approach typically requires one observer to spend an extended period of time uncovering cultural norms at one site. In contrast, a rapid ethnographic approach uses a team-based approach for data collection and analysis and the observation is focused on a specific issue (ie, provider use of EHR and related workarounds).[25] This approach also considers the target issue from several perspectives (ie, nurses, physician, medical assistants, etc).

Included in these observations were both paper-based and computer-based workarounds to EHR use, which were the focus of the secondary analyses reported here. During observations, two to four observers experienced in ethnographic observation individually shadowed providers as they interacted with the EHR during a work shift. Observers noted conversations with patients and other staff, actions taken with the EHR, paper-based artifacts, and EHR screens used. Written observations were recorded on a structured form during participant interaction with the EHR, capturing observable activities and verbalizations. The structured observation form included three columns: one to identify participant and observation, one for a time stamp, and one for the actual observation (details about players and content).

To better understand the observational data, observers asked opportunistic questions of providers on their use of the EHR during the observation period. They asked providers why they took certain actions using the EHR. Additionally, observers asked providers for their opinions and feedback about the use of the EHR (eg, What do you like about the EHR? Are there barriers to treatment caused by the EHR?). These responses aided understanding of providers' actions and perceptions of the EHR. To limit disruptions, observers did not ask opportunistic questions when patients were present. Responses to opportunistic questions were recorded on the structured observational form with observations.

Data collection

For each site, investigators conducted observations during two full days. These observations included shadowing providers during patient visits. Verbal consent was obtained from each patient before observing an examination, according to the approved institutional review board protocol. Healthcare workers included in the observations read and signed an informed consent if they chose to participate. Handwritten observations were typed after each site visit, and a scheme was applied to permit tracking of observer, site, clinic, and day. Data were collected from March, 2008 to October, 2008.

Data analysis

Two authors (human factors engineer, social psychologist), first, independently reviewed the entire body of observation data (which included responses to opportunistic questions) from two sites and extracted all observations that were relevant to workarounds. We included an observation as a workaround if providers used paper forms or notes in place of the EHR, or if providers were using the EHR in a non-normative manner. The responses to opportunistic questions were included with the observation data for analysis. We considered this information as inseparable from the observational data since these were unplanned questions asked specifically to clarify what was being observed in real-time. The two researchers then met to reconcile the final extracted dataset from which to code. Differences in the independently extracted datasets were resolved by consensus. For the other two sites, one researcher (social psychologist) extracted the relevant observations and the other researcher (human factors engineer) reviewed them for inclusion or exclusion. Any disagreements about inclusion were discussed and consensus reached. Using this subset of data, the two coders independently coded the observations in two steps. First, each observation was coded as a paper-based or computer-based medium for the workaround. Second, coders applied 11 a priori codes for the type of workaround to EHR use (see table 2 for code definitions).[26] However, using a grounded theory approach, new categories were also allowed to emerge during the coding. In some cases, observations were coded as multiple workaround types.

Additionally, during this process, coders used analytic memos to summarize the content and actions included in coded observations. All differences in the independently coded observations were resolved by consensus through a series of six additional meetings. Every difference in coding was discussed by the two coders until consensus was reached. After coding and consensus, Microsoft Excel was used to sort segments by category. Once sorted, the two coders reviewed each category and used upward abstraction to summarize each category. In other words, the data were represented at a higher level of abstraction such that observations could be integrated across cases to show patterns of behavior or workarounds. After individual examples were placed into categories, the coders met to discuss the contents of each category, identify themes, and summarize commonalities across examples.

RESULTS

Our findings are organized such that each type of workaround is categorized as being observed in three, two, or one of the three benchmark institutions (see table 2).

Findings observed across three institutions

Workarounds to EHR for reasons of efficiency, awareness, and memory were consistent across all three benchmark institutions.

Table 2 Reasons for paper- and computer-based workarounds to the electronic health record system across three benchmark institutions for health information technology

Reason for workaround	Definition	Institutions	Workaround medium
Observed across three institutions			
Efficiency	Using a workflow process that improves actual or perceived efficiency	VHA, RI, PHS	Paper, computer
Memory	Reminder about 'old' or existing information	VHA, RI, PHS	Paper, computer
Awareness	Recognize new/important information: notify, alert, trigger, adjusting 'signal-to-noise' ratio	VHA, RI, PHS	Paper, computer
Observed across two institutions			
Knowledge/skill/ease of use	Training/support/experience/ease of finding needed information	RI, PHS	Paper, computer
Task complexity	Complexity of task dictates workflow issues or functionality issues	VHA, PHS	Paper
Trust	Greater trust in paper over electronic version	RI, PHS	Paper
No correct path*	A desired option did not exist in the computer workflow	VHA, RI	Computer
Observed within one institution			
Data organization	Data layout issues; need to view existing data differently	VHA	Paper, computer
Task specificity	Need specificity or ability to customize to patient, provider, department, etc; some signal-to-noise concerns	VHA	Paper
Sensorimotor preferences	Preferred sensory input for task: 'hear', 'tangible', easily modified (ie, hand-written notes); mobility, something to 'deliver'	PHS	Paper
Longitudinal data processes	Task requires processing multiple data points across time	VHA	Paper

*A new category not part of the original coding developed from previous work.
PHS, Partners HealthCare System; RI, Regenstrief Institute; VHA, Veterans Health Administration.

Efficiency workarounds included actions that health professionals perceived to make their work go more quickly. Efficiency was cited as a reason for using both paper-based and computer-based workarounds, though the specific workarounds were different.

Efficiency workarounds that were paper-based were of two types: (1) role division and (2) patient questionnaires or patient medication lists to update. In the first type, a health technician was informally designated as responsible for entering patient information into the EHR. If this person was not available for computer entry during the patient in-take, then paper notes were made with vitals and responses to screening questions for later data entry. In the second type, patients completed health screenings as a paper-based questionnaire or reviewed their medication list for accuracy (as printed from the EHR). The health screenings questionnaire included questions directly from a clinical reminder and was primarily used when the clinic was busy, allowing only limited time to ask patients questions directly. Alternatively, the health screenings, which are used to satisfy clinical reminders, would be completed during a face-to-face conversation with patients to assess depression or other conditions. Additionally, in one observation, a health technician indicated that patients 'don't answer it very accurately. They'll just put anything down and they share this information with me.' However, clinic staff reported that this method was efficient because patients could complete the task on their own while waiting.

The most frequent example of computer-based workarounds for efficiency was copying and pasting text from previous patient progress notes into a new progress note. In another case, a physician copied vitals or health maintenance information into a new note. Although copying and pasting text is an allowable function, it is against hospital policy for creating progress notes and therefore meets our definition of a workaround. As noted by observers, copying and pasting text is used to save time (workaround to improve efficiency). One physician copied laboratory results in an email to request a consultation from another physician rather than follow the designated procedure for a consultation request.

Awareness workarounds included notifying or alerting a coworker of new or important information. These workarounds served as a means of communication whether they were paper-based or computer-based. For the majority of these instances, clinic staff made notes on paper-based patient encounter forms to notify a provider about patient information. For example, staff members wrote down vitals at in-take or results from a health screening on the encounter form (in addition to entering information into the EHR) so that this information was readily available during the patient examination. The computer-based workarounds in the awareness category included similar actions. Specifically, in one example, a nurse practitioner made a note on the computer-based problem list about continued surveillance using colonoscopies every 3 years. Note, this was not an actual 'problem' or medical condition, as intended for a computerized problem list, and thus considered a computer workaround. Here, the provider used the computerized problem list to communicate a surveillance issue to other providers. In this instance, the note was for any provider seeing the patient in the future; while the paper-based workarounds in the awareness category were specific notes about a current patient visit.

Memory workarounds included cues for completing future tasks. These paper-based workarounds typically included making notes for completing a task later or to follow-up a patient problem. For example, one nurse indicated that she preferred to complete the influenza clinical reminder and then write 'flu shot' on a scrap of paper to remind herself to actually administer the shot. Also, a physician assistant would keep print outs from the EHR as a reminder to finish unsigned progress notes. Computer-based workarounds that served as memory aids included creating clinical messages to oneself that served as a reminder for following up with patients or completing other tasks.

Findings observed across two institutions

Workarounds to EHR use related to knowledge/skill/ease of use, task complexity, trust, and 'no correct path' were consistent findings across two of three institutions. The knowledge/skill/ease of use category applied to three situations: (1) lack of knowledge of the EHR or related health IT systems; (2) poor individual skill level with computerized tools; and (3) difficulty in use of health IT tools.[26] The paper-based workarounds involved printing out notes owing to difficulties in switching between computer screens, and problems in learning how to use a computer system. One instance involved a provider who could not locate test results in the EHR. After looking for the results, the patient offered to fax the results. Only one computer-based workaround fit this category. In this observation, a provider could not place an order without closing the progress note because the note would be deleted. To get around this problem, the physician relogged into a second session to enter the orders.

Task complexity included workarounds for which the complexity of the task led to workflow problems. Only paper-based workarounds were identified here. For example, at one clinic, staff needed to readily know the reason for the patient visit and also needed the patient to update demographic information. To create a process that accomplished both needs, clinic staff would print two copies of the demographic sheet. One copy was used for writing the reason for the visit along with vitals and then transferred to the provider. Another copy of this form was printed out and given to the patient to review and note any corrections. In this example, the EHR was bypassed because it did not list the reason for the patient visit and patients could not use it to update demographic information.

Trust-related workarounds included those where a provider noted greater trust in paper over electronic tools. By definition, these workarounds were only paper-based. These workarounds included making paper-based notes to use for writing progress notes. The distinction for this category was that concerns were expressed about the reliability of the EHR being available when they needed access to it for writing a progress note. Another example was a medical assistant who would write down a brief summary for patients' reasons for their visit in case the EHR was not available when a patient arrived for an appointment.

Although reasons for paper-based workarounds also applied to computer-based workarounds, a single new code emerged, unique to the computer-based cases: 'no correct path'. No correct path included workarounds where a provider did not have the necessary options on the computer interface to complete a desired action; and, therefore, would develop his/her own process for completing a task even if, in some cases, it led to inaccuracies in patient data.

In one example, when a physician assistant was completing a lipid screening computerized clinical reminder, she noted that none of the options pertained to the patient. She selected 'Lipid profile ordered', even though it was inaccurate, and included a comment to explain the patient's situation. Another example involved a physician who stated that when a colonoscopy is scheduled, but not yet completed, the colonoscopy reminder

still appears. In this situation, the physician will select 'Patient declined' colonoscopy to satisfy the reminder. In several other instances, the provider was playing the system. In these cases, the programming logic for submitting orders or prescriptions prohibited an action. To get around these limits, the provider altered the reason for the order or the quantity of the medication, even though these alterations led to inaccuracies in the EHR. Table 3 shows examples of this category.

Findings observed within one institution

Workarounds to EHR use for reasons of data organization, task specificity, sensorimotor preferences, and longitudinal data processes were identified in a single institution. That is not to say that these types of workaround do not necessarily exist at the other institutions. Rather, they were not apparent in the secondary analysis of this particular dataset. For example, although workarounds related to sensorimotor preferences were seen only at Partners HealthCare System in this dataset, they were also documented at VA in previous research.[26] In cases related to data organization, providers desired to view patient information differently from the way in which it was presented on the computer to better support their work. One example each from paper-based and computer-based workarounds was identified. For the paper-based workaround in this category, separate paper-based router sheets were created to organize patient information. For the corresponding computer-based workaround, a provider purposefully misclassified active problems she perceived to be lower priority as 'inactive' such that they appeared at the bottom of the list. In this example, the provider would organize patient information to support her work so that the desired patient information was readily accessible. This action of misclassifying active problems is a workaround to retrieving patient problems as a non-prioritized problem list that is typically displayed in the EHR.

Task specificity refers to the need to customize information that is specific to the patient, provider, or clinic.[26] In this dataset, we observed providers using either a paper spreadsheet or notebook to track CRC screening (eg, completion of fecal occult blood test cards and colonoscopy). The relevant information was available using the EHR. However, this information, including dates of screening procedures, results, and upcoming screenings, was not gathered together in such a way that tracking CRC screening was straightforward.

Workarounds involving sensorimotor preferences included instances where the provider would favor a specific sensory input for a task. For example, one physician preferred to maintain eye contact during the patient examination as much as possible and so relied on a paper-based cover sheet to discuss medication and other health concerns. In this situation, the physician would complete progress notes at night. In the other instance of a sensorimotor preference workaround, a nurse practitioner preferred to view x-ray findings both in the EHR and on paper in order not to miss anything abnormal or suspicious.

Workarounds relating to longitudinal data processes included tasks that required processing multiple data points across time. For example, at one site, a health technician tracked fecal occult blood test card returns for each month in a paper notebook. For each patient, phone numbers and date of calls to remind patients to return their cards were recorded in the notebook. The intention was to develop a tool that would allow looking across patients over time to identify everyone who was due for CRC screening. In many cases, this pro-action facilitated by the paper notebook enabled the clinic to meet the deadline before the screening was recorded as being late by the EHR.

Table 3 Examples of 'no correct path' computer-based workarounds

Description	Observation or opportunistic question response
Using incorrect but equivalent computer documentation to match actual plan	Physician: 'We tell them to split that pill (for blood pressure) but the EHR med list will only show the full pill and then there's a mismatch (in timing of when the medication needs to be renewed). That's a problem. There's all these little things we have to do' (to correct for and make the system work)
Clicking inaccurate option to satisfy reminder since none is the 'right' one	Nurse practitioner indicates that the CRC reminder sometimes has no good option. If a colonoscopy is already scheduled, the reminder still comes. It asks when it was last done, but doesn't allow you to enter that one is scheduled. She clicks the box that says patient has declined the colonoscopy to turn off the reminder
Gaming the system: change to medication order to comply with system requirements ('cannot dispense this quantity')	Physician 1 is using EHR to order medicine for a patient. She is receiving alerts indicating '…cannot dispense this quantity…' Physician 1 complains to physician 2 next to her that the orders are 'not taking' and explaining what she's doing to get the 'orders to take'. (by 'getting the orders to take' she means being accepted by the EHR order entry system)

CRC, colorectal cancer; EHR, electronic health record.

DISCUSSION

We characterized workarounds at three benchmark institutions for heath IT. The workarounds identified in this study were consistent with previously defined categories of paper-based workarounds to EHR use.[26 27] Since these categories represent the underlying reasons for workarounds, they were also applicable to the computer-based workarounds; extending this workaround typology to computer-based workarounds is a unique contribution of this study. We also identified an additional category for the computer-based workarounds: 'No correct path' (eg, a desired option did not exist in the computer workflow, precipitating a workaround). The multi-site design of this study supports the generalizability of the findings observed across more than one institution.

Different EHR systems, same workarounds

Although observations were made at three institutions, similar workarounds were identified across these different institutions and EHRs. Awareness, memory, and efficiency related workarounds were seen at all of the benchmark institutions, suggesting some consistent weaknesses in EHRs. Awareness reasons for workarounds primarily suggest that communication among care providers is a problem in clinics. Typically, a team-based approach to patient care is used and the EHR needs to reflect this approach. The EHR could potentially include a mechanism for providers to communicate about patients.

Likewise, in situations where there are many complex tasks and patients, constructing memory cues for completing work is necessary. These types of memory cues are examples of prospective memory aids which serve as a prompt to complete a task in the future. Work settings that require multi-tasking and

are characterized by frequent interruptions and distractions carry a particularly high load for prospective memory.[28 29] EHR designers might leverage this knowledge to explore strategies for providing reminding and alerting cues. Based on findings from our study, as well as a growing body of publications,[30–32] designers of the next generation of reminders and alerts should consider:

- providing alerts to the right member(s) of the healthcare team at the right time; avoiding too many alerts (leading to alert fatigue and workarounds);
- providing prospective memory aids for well-understood tasks, and the ability to easily and efficiently create prospective memory aids in real time for unexpected and unpredictable tasks;
- providing reminders and alerts that support the provider in quickly assessing relevant information and recognizing important actions.

The challenges of prospective memory are further exacerbated in busy clinics with many patients, where efficiency is a significant concern among providers. Other studies also report workarounds due to efforts to improve efficiency.[9 15 33] As noted in our study, providers need to be able to efficiently construct their notes in a way that is consistent with hospital policy. While subjective parts of a previous note should not be copied, factual information could be made available for duplication. A user-centered design approach could be achieved by working with providers to understand the objective parts of previous notes that should be permitted to be imported into a new note, or making those objective parts available as a module separate from a specific note that can simply be referenced. These solutions could potentially help providers to become more efficient in their documentation tasks while reducing the need for a copy and paste workaround.

With consistent workarounds identified across outpatient clinics, the same pressures are evident: communicating among providers, keeping up with work demands, and multi-tasking effectively. EHRs might be designed to support cognitive demands and tasks in ways dealt with by the identified workarounds.

Paper-based, computer-based, or both

Interestingly, some of the workarounds were only paper-based or computer-based. Five categories of workarounds were observed only as paper-based. Two of these (trust and sensorimotor preference) may relate more to the switch from a paper-based system to one that is less paper-based. It is possible that individuals accustomed to a paper-based system might trust this system over electronic systems and also prefer to view information on paper. However, some paper tools have powerful, inherent advantages that cannot be replicated electronically. For example, some workarounds suggest that complicated tasks are difficult to program within the EHR or programmers do not know what work processes need cognitive support from EHR. These three workaround categories include task complexity, task specificity, and longitudinal data processes. In their study of a barcode medication administration system, Patterson and colleagues observed a situation similar to task specificity workarounds where a task was difficult using the available health IT tools. Specifically, to order a 'taper dose,' the pharmacist was required to enter multiple new orders for the exact dose for each day.[15] For all these categories, providers were creating processes to complete tasks that supported patient care but that did not lend themselves to EHRs. These types of tasks required pulling information from different sources (ie, EHR, patients, other healthcare facilities, other departments) and organizing this information in such a way that the task at hand could be completed.

Wears and Perry reached similar conclusions in their exploration of the use of 'shadow charts' in an emergency department.[34 35] Observers noted that physicians kept careful hand-written notes throughout the day that were used to track patient progress, as prospective memory aids, and to guide discussions at handoff. Shadow charts were generally believed to be more accurate and up-to-date than the patient information in the EHR. These shadow charts were seen as a cognitive aid in that physicians found that they helped with thinking, prospective memory, and coordination. The EHR, on the other hand, was seen as a task to be completed for the purposes of documentation and billing. Thus, there may be some value to users in creating their own record of events and reminders for future events. The challenge for designers is to develop EHRs that make these cognitive support functions more salient, and move other, potentially competing functions, such as billing, to the background.

The category that only pertained to computer-based workarounds suggests opportunities for improving EHRs. 'No correct path' workarounds clearly show where the EHR failed to support providers in their work. A second aspect of this category, involving playing the system, suggests that providers can work the system when there is some flexibility to meet their needs. Similar to no correct path workarounds, Koppel and colleagues documented unauthorized steps among nurses using a barcode medication administration system.[9] For example, they observed nurses giving partial doses of medications but documenting that the full dose was administered because the medication was not dispensed in the quantity needed. Probably in our study, as well as in Koppel's study, problems arise with health IT tools when options or functions do not match the necessary or preferred clinical work practices. The design process for computer interface or EHRs should include user-centered methods and input. Otherwise, workarounds may manifest if the provider is expected to adapt to limiting technological design.

Although some would classify any sort of workaround as a failure of design, we posit an alternative viewpoint. It might be unrealistic to expect that EHRs will ever eliminate the need for user-created, paper-based cognitive support. Rather, a more appropriate goal might be to design systems to support the cognitive challenges that are understood and expected, and also to provide the user the flexibility to adapt as unexpected challenges occur. One advantage of low-tech media such as paper notes and white boards is that they allow for efficiency and adaptability. Users can quickly and easily create prospective memory aids for non-routine events, reconfigure data to highlight elements that are important in a specific context, or track data over time that may become important later in solving a specific problem. Furthermore, these low-tech media have a transitory quality. They can be crumpled up and thrown away (or erased) if they do not turn out to be useful or are no longer useful. Electronic systems, on the other hand, create a permanent record that can easily be subverted for uses beyond those intended by the user (ie, to support billing and financial operations).

Recent studies of the transition from paper charts to computerized charts and from white-board status boards to electronic status boards highlight these aspects of low-tech media that are difficult to reproduce in electronic support systems. Retention of white boards and the use of paper-based shadow charts after electronic tools have been implemented is more than resistance to change on the part of the users. The ability to efficiently create cognitive aids as the nature of work evolves—often in ways that are unexpected—is critical. The highly dynamic and

rapidly evolving nature of the healthcare domain suggests that it will not be enough for designers to create effective EHRs for well-understood challenges. They must also provide users with the tools they will need to quickly adapt to rapidly changing, new challenges.[36 37]

Limitations

The data available for this study represent a relatively small portion of the entire set of ethnographic observations. As a result, caution should be used in generalizing these findings to other clinics, providers, and healthcare facilities. Although we found consistency across sites in most categories of workarounds, three categories were seen in only one site. However, two of these three types of workarounds were observed in previous work, thus providing support that they are robust reasons for workarounds. Further work should be conducted to validate the new computer-based workaround discovered in this study.

CONCLUSIONS

We applied a coding scheme previously developed with paper-based workarounds to both paper-based and computer-based workarounds at three benchmark institutions. Ten of the original 11 categories were present in this analysis; three of these types of workaround were seen across all three EHR systems. Additionally, the 'no correct path' workaround was developed to represent a new type of workaround that had not previously been seen.

Despite variable EHR systems and work processes at these three benchmark institutions, several types of workarounds were consistently seen. These consistencies may suggest common challenges in outpatient clinical settings and failures to accommodate these challenges in EHR design. Viewing the types and modes of workarounds identified in this study as evidence of cases where the EHR did not adequately support the needs of the providers, may provide initial guidance for revisions to current EHR systems and to EHR development.

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REFERENCES

1 Majority Staff of the Committees on Energy and Commerce, Ways and Means, and Science and Technology. Health Information Technology for Economic and Clinical Health Act or HITECH Act. January 16, 2009. http://waysandmeans.house.gov/media/pdf/110/hit2.pdf (accessed 19 Jul 2012).
2 Committee on Quality of Health Care in America. *To err is human: building a safer health system*. Washington, D.C: National Academies Press, 2000.
3 Committee on Quality of Health Care in America. *Crossing the quality chasm: a new health system for the 21st century*. Washington, D.C: National Academies Press, 2003.
4 Bloomrosen M, Starren J, Lorenzi NM, *et al*. Anticipating and addressing the unintended consequences of health IT and policy: a report from the AMIA 2009 Health Policy Meeting. *J Am Med Inform Assoc* 2011;18:82–90.
5 Campbell EM, Guappone KP, Sittig DF, *et al*. Computerized provider order entry adoption: implications for clinical workflow. *J Gen Intern Med* 2008;24:21–6.
6 Cresswell KM, Worth A, Sheikh A. Integration of a nationally procured electronic health record system into user work practices. *BMC Med Inform Decis Mak* 2012;12:15.
7 Aarts J, Ash J, Berg M. Extending the understanding of computerized physician order entry: Implications for professional collaboration, workflow and quality of care. *Int J Med Inform* 2007;76(Suppl 1):4–13.
8 Halbesleben JRB, Savage GT, Wakefield DS, *et al*. Rework and workarounds in nurse medication administration process: implications for work processes and patient safety. *Health Care Manage Rev* 2010:35;124–33.
9 Koppel R, Wetterneck T Tosha, Telles JL, *et al*. Workarounds to barcode medication administration systems: their occurrences, causes, and threats to patient safety. *J Am Med Inform Assoc* 2008;15:408–23.
10 Karsh BT, Weinger MB, Abbott PA, *et al*. Health information technology: fallacies and sober realities. *J Am Med Inform Assoc* 2010;17:617–23.
11 Ferneley EH, Sobreperez P. Resist, comply or workaround? an examination of different facets of user engagement with information systems. *Eur J Inform Syst* 2006;15:345–56.
12 Gurses AP, Xiao Y, Hu P. User-designed information tools to support communication and care coordination in a trauma hospital. *J Biomed Inform* 2009;42:667–77.
13 Vogelsmeier AA, Halbesleben JRB, Scott-Cawiezzel JR. Technology implementation and workarounds in the nursing home. *J Am Med Inform Assoc* 2008;15:114–19.
14 Patterson ES, Cook RI, Render ML. Improving patient safety by identifying side effects from introducing bar coding in medication administration. *J Am Med Inform Assoc* 2002;9:541–53.
15 Patterson ES, Rogers ML, Chapman RJ, *et al*. Compliance with intended use of bar code medication administration in acute and long-term care: an observational study. *Hum Factors* 2006;48:15–22.
16 Suchman L. *Plans and situated actions*. Cambridge: Cambridge University Press, 1987.
17 Chaudhry B, Wang J, Wu S, *et al*. Systematic review: impact of health information technology on quality, efficiency, and costs of medical care. *Ann Intern Med* 2006;144:742–52.
18 Saleem JJ, Militello LG, Arbuckle N, *et al*. Provider perceptions of colorectal cancer screening clinical decision support at three benchmark institutions. *AMIA Annu Symp Proc* 2009:558–62.
19 Bates DW, Pappius E, Kuperman GJ, *et al*. Using information systems to measure and improve quality. *Int J Med Inf* 1999;53:115–24.
20 Wright A, Pang J, Feblowitz JC, *et al*. Improving completeness of electronic problem lists through clinical decision support: a randomized, controlled trial. *J Am Med Inform Assoc* 2012;19:555–61.
21 Brown SH, Lincoln MJ, Groen PJ, *et al*. VistA—U.S. Department of Veterans Affairs national-scale HIS. *Int J Med Inform* 2003;69:135–56.
22 Department of Veterans Affairs: Health Data Systems, Computerized Patient Record System Product Line. Computerized Patient Record System (CPRS): Setup Guide. April 2011:2–4. http://www.va.gov/vdl/documents/clinical/comp_patient_recrd_sys_%28cprs%29/cprssetup.pdf (accessed 19 Jul 2012).
23 McDonald CJ, Overhage JM, Tierney WM, *et al*. The Regenstrief Medical Record System: a quarter century experience. *Int J Med Inform* 1999;54:225–53.
24 Simonaitis L, Belsito A, Overhage JM. Enhancing an ePrescribing system by adding medication histories and formularies: the Regenstrief Medication Hub. Annual Symposium Proceedings/AMIA Symposium; 2008: 677–81.
25 McMullen CK, Ash JS, Sittig DF, *et al*. Rapid assessment of clinical information systems in the healthcare setting: A timely method for time-pressed evaluation, methods of information in medicine. *Methods Inf Med* 2011;50:299–307.
26 Saleem JJ, Russ AL, Justice CF, *et al*. Exploring the persistence of paper with the electronic health record. *Int J Med Inform* 2009;78:618–28.
27 Saleem JJ, Russ AL, Neddo A, *et al*. Paper persistence, workarounds, and communication breakdowns in computerized consultation management. *Int J Med Inform* 2011;80:466–79.
28 Dekker S. *Patient safety: a human factors approach*. Boca Raton: CRC Press, 2011.
29 Grundgeiger T, Sanderson PM, MacDougall HG, *et al*. Distributed prospective memory: an approach to understanding how nurses remember tasks. *Proceedings of the Human Factors and Ergonomics Society 53rd Annual Meeting*; Santa Monica, CA: HFES, 2009: 759–63.
30 Kawamoto K, Houlihan CA, Balas EA, *et al*. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *BMJ* 2005;330:765.
31 Saleem JJ, Patterson ES, Militello L, *et al*. Exploring barriers and facilitators to the use of computerized clinical reminders. *J Am Med Inform Assoc* 2005;12:438–47.
32 Grundgeiger T, Sanderson P, MacDougall HG, *et al*. Interruption management in the intensive care unit: Predicting resumption times and assessing distributed support. *J Exp Psychol App* 2010;16:317–34.

33 Ash JS, Sittig DF, Campbell EM, *et al*. Some Unintended Consequences of Clinical Decision Support Systems. *AMIA 2007 Symposium Proceedings*; 26–30.
34 Wears RL, Perry SJ. Shadows and ghosts: the role of hidden information in a US healthcare setting. *Proceedings of the International Ergonomics Association 2006 Congress*. Maastricht, Netherlands: International Ergonomics Association, 2006.
35 Wears RL. The chart is dead—long live the chart. *Ann Emerg Med* 2008;52:390–1.
36 Xiao Y, Fairbanks RJ, Gurses AP, *et al*. User created cognitive artifacts: what can they teach us about design of information technology? *Proceedings of the Human Factors and Ergonomics Society 53rd Annual Meeting*. Santa Monica, CA: HFES, 2009: 694–8.
37 Roth EM, Scott R, Deutsch S, *et al*. Evolvable work-centered support systems for command and control: Creating systems users can adapt to meet changing demands. *Ergonomics* 2006;49:688–705.

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