Design In The "Medical" Wild: Challenges Of Technology Deployment

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Abstract
We describe the challenges of deploying a digital checklist for medical emergencies during an in-the-wild design and evaluation study. The in-the-wild approach allowed for many design iterations to meet the requirements of a safety-critical setting, while also providing lessons for designing in the wild. We faced two major challenges: working with research coordinators as study mediators and adapting training strategies to busy user schedules. We discuss these challenges and approaches to addressing them.

Author Keywords
Digital checklist; in-the-wild design; clinical checklist; emergency medicine; trauma resuscitation.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

Introduction
In this ongoing work, we seek to design in the wild [8] through the deployment of a novel system in an emergency medical setting—a digital checklist for trauma resuscitation. Our overall goal is to understand how the real-world technology use affects medical work, thus informing the checklist design to address the requirements of the setting. To achieve our goal, we deployed the digital checklist over eight months in

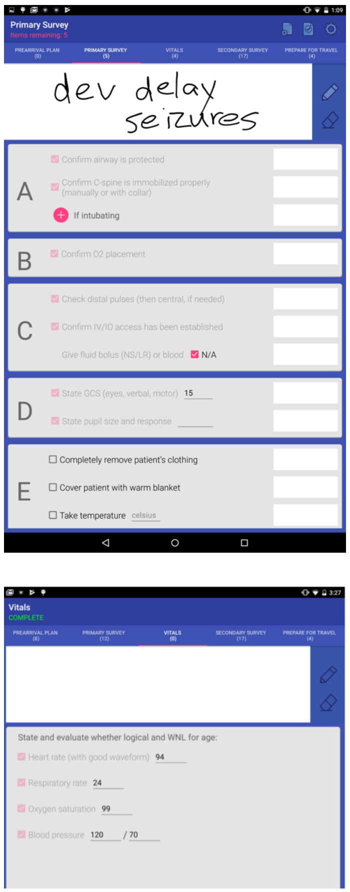

Figure 1: Primary survey tab showing items checked and a margin note (*top*), and the vitals tab with values entered (*bottom*).

the trauma center of an urban, pediatric teaching hospital. Thirteen surgery fellows and residents used the checklist in a total of 116 trauma resuscitations. During the study period, we were collecting user feedback and data about interactions with the checklist through system logs and interviews. Using these data, we then iteratively improved upon the design and deployed those changes in an agile fashion. Although we encountered many challenges, we were able to truly understand user needs and technology use behaviors, which in turn led to lowering barriers to adoption. In this short paper, we focus on the challenges with the in-the-wild design approach and how it affects the technology use and overall adoption.

Background

Rogers and Marshall [8] describe research in the wild as an approach to observing how people react, change and integrate technology into their everyday lives over a period of time. HCI researchers have used this approach, experimenting with technological possibilities that can alter behaviors rather than designing solutions to fit into existing practices. Examples range from exploring the use of robots in healthcare [2] to using mobile devices for tracking personal health activity [1], to studying how a shared planning application for a walk-up-and-use tabletop was used when placed in a tourist information center [5].

Because regulations for implementing technology in healthcare are strict, especially for emergency medical work, few studies have used research in the wild in clinical settings [4]. With this work, we contribute to the growing body of research on designing in-the-wild by describing the challenges of using this approach in a complex work setting and how to address them.

Digital Checklist for Trauma Resuscitation

Trauma patients arrive to the hospital with a range of complex injuries and problems. To standardize the care of injured patients and improve outcomes, trauma teams follow the Advanced Trauma Life Support (ATLS) protocol, focusing on the major physiological systems (primary survey) and detailed evaluation of other injuries (secondary survey), but deviations from the protocol are common. To help trauma teams improve protocol compliance and reduce delays, our research site introduced a paper-based checklist for trauma team leaders [6]. We based the design and layout of our digital checklist on those of the paper checklist (Figure 1). The checklist has five sections: pre-arrival plan (preparatory tasks), primary survey (ABCDE tasks), vital signs, secondary survey, and prepare for travel (departure tasks). We included an area for note taking on top of the screen to allow for writing margin notes, and individual note areas for each checklist item. A written note is minimized into a thumbnail, so it remains visible (Figure 2). Checklist items that include numerical values (e.g., weight, vitals) can be typed in using dedicated fields. Before finishing the checklist and submitting the log file, users can review and complete any unchecked items. The checklist was first designed and developed for a tablet using Android Studio.

Methods

Our study site is a 280-bed acute care hospital with a level 1 trauma center that treats about 1,000 injured children each year in one of two trauma rooms.

Participants

The study participants were 13 trauma team leaders who used the checklist for their work during resuscitations. All team leaders were asked to consent

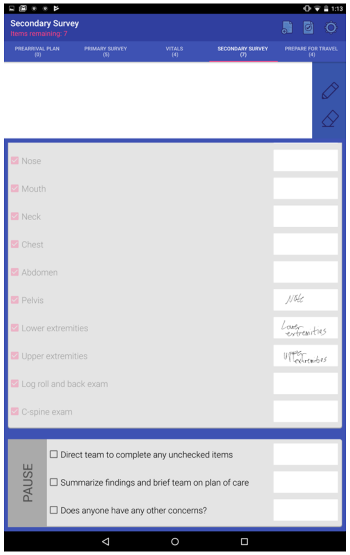

Figure 2: Secondary survey showing note thumbnails.

to using the digital checklist before starting with real-world use. During the study, team leaders could choose between the paper and digital checklist.

Research Coordinators
Three research coordinators at the hospital supported the study and served as our liaisons with the team leaders. The first research coordinator (RC1) was a pre-med student with some expertise in trauma resuscitation. His role was to update the system when software changes were made, support checklist use during daytime events, train new users, and coordinate scheduling of the interviews. Six months into the study, RC1 left and another research coordinator, also a pre-med student, filled in this role (RC2). The third research coordinator (RC3) is a surgery fellow who works in a similar capacity as RC1 and RC2, but also takes on the team leader's role during resuscitations.

Digital Checklist Logs & Interviews
Over the eight-month period, we collected 116 digital checklist logs, 29 of which were completed by RC3. RC1 and RC2 reviewed the log files to remove any patient identifying information before analysis. The logs include checked items and timestamps for those checks (e.g., "22:45:15 Log roll and back exam"), values from typed notes, handwritten notes and corresponding checklist items, and any unchecked items. Using these logs, we analyzed checking patterns and the handwritten and typed notes to determine how changes throughout the study affected use behaviors.

After a team leader used the checklist three or more times, we scheduled an hour-long, one-on-one interview to discuss their experiences and areas for improvement. During the interviews, we ask about system interactions like note taking and tab switching, and how using the checklist affects leaders' coordination and communication with team members. All interviewed leaders received monetary compensation. We also interviewed one of the research coordinators (RC1) to better understand how they felt about their role and responsibilities. We perform a thematic analysis of interview data to identify themes related to checklist use practices and challenges.

Results
A total of 352 trauma resuscitations occurred during the study period. The paper checklist was used in 122 resuscitations, digital checklist in 116, and 113 resuscitations were conducted without the checklist. The design updates throughout the deployment included: note-taking features to allow typing notes for items that previously could only be handwritten (e.g., temperature); redesigned formatting of the checklist log file; increased resolution for thumbnail snapshots of handwritten notes for better viewing; new icons and buttons; and a new expandable area for recording margin notes. Team leaders used the digital checklist 0 to 37 times, with a median of 6 uses per leader: four team leaders used the checklist 6 times; three leaders, including the RC3, were super-users, using the checklist 37, 29, and 13 times, respectively; and four leaders used it only 3 or fewer times, preferring the paper form. One leader did not use the digital checklist at all. On average, team leaders took 2.8 notes on the checklist (SD 0.7), ranging from 0 to 14 notes. Among the notes, 40 were margin notes. Despite these positive results, the checklist adoption was affected by two major factors: leaders' training on the system and changes in user population due to frequent rotations.

"I couldn't find everything on the digital checklist as quickly. It is laid out in a logical manner but trauma resuscitation doesn't always go in order. Often times many things are happening at once, so the pre-arrival stuff ok, but then the junior resident is shouting out exam findings at the same time as you're getting vitals from the nurses at the same time as you're deciding in your head, sick patient, or really sick, or not sick … and on the paper checklist it is all right there in front of you, but in the tablet, I was trying to catch up the whole time, did I fill that box, go up go down, go back, go forth."

Figure 3: Quote from one of the senior residents during an interview.

Training Sessions for Team Leaders

The format for training users on the digital checklist changed during the study period to adapt to the busy schedules of trauma team leaders. Four team leaders, including RC3 in his fellow role, were trained in a group session; six were trained in an ad-hoc manner, just before their first checklist use during an actual trauma resuscitation; and, three leaders were trained at the beginning of their rotations during the hospital-wide orientation to trauma resuscitation. The group training session was conducted as part of the study initiation at the research site with four team leaders. These leaders were already working at the hospital and used the paper checklist. We quickly went through the layout and features of the checklist and then asked the leaders to explore the interface. Training subsequent leaders was delegated to the research coordinators because they are co-located at the hospital. To ensure that training of new users followed the same procedure, we "trained" the coordinators on how to train team leaders. Due to busy schedules and time constraints, training of six new leaders was conducted right before their first checklist use in the trauma room. As recounted by the coordinators, the leaders received a run through the digital checklist and then moved onto using it for the first time in situ. This training method affected the checklist use, contributing to low system adoption among these leaders. The leaders trained in this ad hoc manner interacted with the checklist 29 times total, took very few notes, but also left very few items unchecked, on average 0.8 items per checklist.

After observing a drop in checklist uses, one of the research coordinators suggested coupling the digital checklist training with that of the paper checklist during the mandatory hospital-wide orientation to trauma resuscitation. As a result, team leader training changed again at the end of the sixth month into the study. Three of the leaders trained in this new way explained that their style of completing the checklist is to check things off as they go and only take notes about abnormal exam findings. They also provided some insight about incomplete checklists (Figure 3).

Effects of High User Turnover

Four surgery fellows participated in this study: three at the start of the study, one of which left the hospital in July, and one new fellow joined in August. We also had nine senior surgery residents, two at the beginning and seven entering throughout the remainder of the study. Most of the rotations overlapped, with the exception of the end of March and beginning of April turnover. During the months of March, April and May, the digital checklist was used 7, 5, and 6 times, respectively. This number is low compared to other months in the study, with an average number of 13 checklist uses per month (SD: 9). During these three months of low checklist usage, senior residents completed one-third of the total checklists and fellows completed two-thirds. Only one case included a handwritten margin note. Most activations were routine cases (10) or transfers (8). From March to May, fewer notes were taken on average compared to the entire study period (2 vs. 3 notes), and more items were left unchecked (1 vs. 0.7 items).

In comparison to these low usage months, June, July and August had the highest number of digital checklist uses (24, 29, and 21 uses, respectively). The senior residents used the checklist 6, 13, and 37 times each. During this period of super-users, the cases were mostly routine activations (47) or transfers (14), but also involved 13 highly acute activations. In June through August, team leaders took an average of 3 notes per checklist and left an average of 5 items unchecked. We found more notes during the acute activations (avg. 4), as well as more unchecked items (avg. 9). In contrast, the routine cases had fewer notes (avg. 2) and fewer unchecked items (avg. 5).

Discussion

We faced two major challenges with this in-the-wild deployment: working with research coordinators as study mediators and adapting training strategies to busy user schedules.

Working with Research Coordinators as Study Mediators
The presence of and assistance from research coordinators at the research site were imperative for the success of this study. These hospital staff members are co-located with the trauma team members, and can quickly detect and address any issues during the study. Instead of working directly with our users, we relied on the research coordinators to serve as the study liaisons, collect informal feedback from team leaders, ensure the system was working (e.g., batteries were charged), and troubleshoot. This arrangement, however, was challenging and led to many missteps and lost data. One of the main challenges was with user training because the RCs did not follow the initial procedures due to busy team leader schedules. Despite these challenges, we realize that this setup—with designers being remote and study administration being left to hospital staff—represents the real world in healthcare IT design and implementation. Studies where designers work directly with a team of doctors or nurses to design and evaluate technology that is deployed in real world are rare [7,9]. It is unrealistic to expect designers and researchers to reside at the hospital and observe every user interaction. More likely scenarios involve large corporations that impose their medical systems onto the users, with little effort going into assessing user needs and designing for "work as done," rather than for "work as imagined" [3]. An approach to overcoming these challenges could include more intense training of the hospital staff to ensure systematic data collection and study administration. Even so, our agile and remote, in-the-wild approach with research mediators at the site and with active user involvement, did have benefits. As the study progressed and users became familiar with the new technology, the checklist use increased and the quality of interactions improved.

Adapting Training Strategies to Busy User Schedules
The initial one-on-one or group training with users was not feasible in the busy and chaotic emergency department. Scheduling group sessions proved to be difficult due to differing shifts and schedules of surgery residents and fellows. We therefore changed the approach to training from scheduling an early session to performing just-in-time training. This change, however, led to inadequate understanding of the system because users did not have time to explore the interface. The training method changed again towards the end of the study, and was more effective because users were now trained on both the paper and digital checklist during a hospital-wide orientation. The main takeaway from this evolution of training methods is the importance of reflecting on how the training may affect the use of a novel technology. It was important to gather feedback from team leaders and adapt the training style as the study progressed to meet the realistic constraints of scheduling while also providing robust training. High turnover of users posed additional challenges because it required training sessions on a

rolling basis. An approach to overcoming these challenges could involve an accompanying video demoing the technology that users can watch at their own pace. Either way, training should be consistent across all users when running a long-term, in-the-wild study. Despite these challenges, our users were able to adapt to using the digital checklist because of the simple, easy-to-use interface.

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