Design In The Wild: Lessons From Researcher Participation In Design Of Emerging Technology

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Abstract
We describe a pilot study of designing and evaluating a digital checklist for medical emergencies based on participation of medical-expert researchers who used the checklist during actual trauma resuscitations. The participation of the researchers revealed challenges and insights for designing in the wild, as well as next steps for using our emerging technology in real scenarios.

Author Keywords
Digital checklist; in-the-wild design; participatory design; trauma resuscitation.

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

Introduction
Trauma resuscitation is a fast-paced, dynamic, and safety-critical process of evaluating and managing a critically injured patient. Due to the complex and high-stress nature of this environment, medical errors are common [4], leading to adverse patient outcomes. Recent implementation of checklists [5] and other decision support systems [1], however, has shown improved protocol adherence and reduced errors. Checklists are cognitive aids designed to reduce human

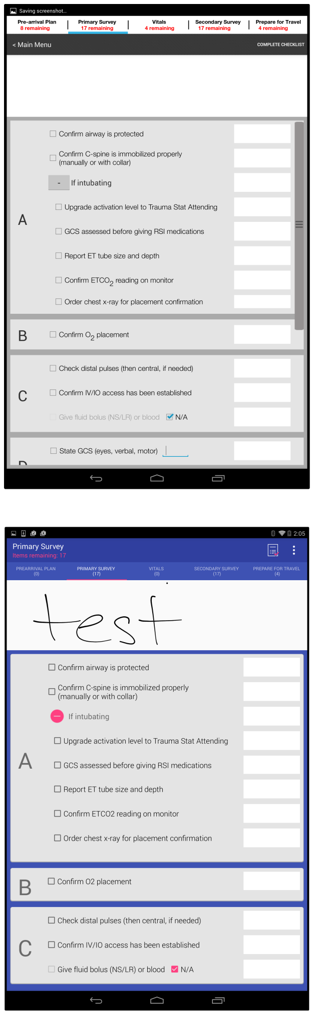

Figure 1: Initial checklist design (top) and revised design used in a trial (bottom).

errors and cognitive workload. Although paper checklists are now common in healthcare, they are static and cumbersome, requiring providers to manually record completion of tasks. Digitizing checklists may lead to further improvements in decision making and care coordination by allowing situation-specific adaptation and faster access to information [8]. Digital checklists will also allow for advanced tracking of use, which can be useful in eliciting requirements for future designs. Many digital checklists have been implemented in simulation environments [2][6], allowing researchers to get close to reality without disrupting actual workflows. In this study, we depart from the simulation environment and deploy and explore our emerging technology—a digital checklist for trauma resuscitation—in the wild [7], with the intention of improving its design. By using this approach, we are gathering data from the natural context where the checklist will be used and providing participants with an opportunity to reflect on their practices and ideate how the technology could be customized for their work. We also contribute to HCI by extending the design in-the-wild approach to a medical domain.

Background: Design In The Wild

According to Rogers, designing in the wild consists of creating and evaluating emerging technologies in situ, compared to traditional approaches of observing existing practices and suggesting system design requirements [7]. The in-the-wild approach flips the traditional laboratory setting, shifting the focus to participants and their environments where there is less control of external factors. With less control, the studies might yield interesting and novel results that were not anticipated. For example, researchers who participated in an in-the-wild study using a gyroscope to measure the length of a violinist's bow movements found it beneficial to experience the user movements rather than imagine them [3]. In our study, the participants are also members of our research team and this approach allows them to experience the design process first-hand. Our goal is to allow participants to test the digital checklist in real scenarios to resolve any system issues before actual deployment. As a result, we are co-designing with participants by gathering their design ideas and iteratively implementing them.

Digital Checklist for Trauma Resuscitation

Paper-based checklist for trauma resuscitation has been mandatory in our collaborating hospital since 2012. This checklist was developed for trauma team leaders to help ensure protocol compliance. The design and layout of the digital version are based on a prior study that analyzed the use of 163 paper checklists to derive design requirements. The checklist application was developed using Android Studio IDE and was written in Java for the Android operating system. The hardware includes a Google Nexus 10 tablet and an Amazon-Basics stylus. The digital checklist includes five tabs, one for each section of the paper checklist: pre-arrival plan, initial patient evaluation (primary survey), vital signs, secondary patient evaluation (secondary survey), and prepare for travel. There is an area at the top for handwritten margin notes, as well as boxes for handwritten notes associated with each of the items on the checklist. Each item has a checkbox next to it. Figure 1 shows the initial checklist design and a revised design that was trialed later in this study.

Methods

Four medical-expert researchers used the digital checklist during daytime trauma resuscitations while shadowing actual team leaders for four months (December 1, 2015 to March 31, 2016). A fifth participant trialed the checklist during July 2016. The digital checklist was used in 16 events, resulting in 14 complete logs (two logs were missing due to system errors). After each use case, participants provided feedback about their experiences. The checklist logs included handwritten notes and timestamps for checked items. We analyzed the data for themes of challenges and design modifications elicited by the participants.

Study Setting

The study took place at a regional level-1 trauma center at a pediatric teaching hospital. The trauma center treats an average of 600 patients per year, with a range of injury mechanisms including falls, burns, firearm, and motor vehicle-related injuries. Patients are assigned one of three activation levels: low acuity (stat), high acuity (attending stat), and transfer. Patient evaluation involves an interdisciplinary team of 7-15 medical providers who assemble ad hoc upon patient arrival. The team follows the Advanced Trauma Life Support (ATLS) protocol, with one member (usually a surgery resident or fellow) in the role of team leader directing others to complete all protocol tasks.

Participants

Our participants used the digital checklist while shadowing the team leader. We instructed participants to use the digital checklist as they would the paper version. All five participants work at the hospital.[1] One participant is a physician with three years of experience in trauma resuscitation. The other four participants are medical experts with research experience in trauma resuscitation. One participant had used the paper checklist as a team leader; the others had not used it but were familiar with the protocol. Before using the digital checklist in situ, all participants underwent training to familiarize with checklist features and functions.

Data Collection

DIGITAL LOG COLLECTION

After using the digital checklist, participants submitted the log file to a password-protected, encrypted cloud server. We collected a total of 14 logs. The log files contained the following data: an image file with all handwritten notes and corresponding items (e.g., “36.8” for the “Take temperature” item in Figure 2), and a text file with a list of checked items with timestamps (e.g., Blood pressure, 12:27:16 PM). Data from each log were transcribed into an excel file containing checklist start time, end time, notes and timestamps, unchecked items, and items checked out of order. This transcript was the basis for our analysis.

PARTICIPANT FEEDBACK COLLECTION

We asked the participants to provide feedback shortly after they used the checklist, while the experience was still fresh in their minds and they would report an accurate account of use. We asked them to explain any issues encountered with the system and provide general comments about use. Most feedback was sent by email, but a few verbal reports were given during the weekly group video conferences. In one instance, a participant shared a video of the tablet screen showing the issue they encountered. We received 16 reports from the participants, including two about system

[1] It is important to note that our participants are all part of our research team, thus the term researcher participation. We, the authors, did not act as participants in this study.

Type	#	Example
Freeform	34	L hip bruise
Numerical	12	4 3 14 6
Numerical with attribute	5	L X R 3mm

Table 1: Frequency and examples of three different types of handwritten notes.

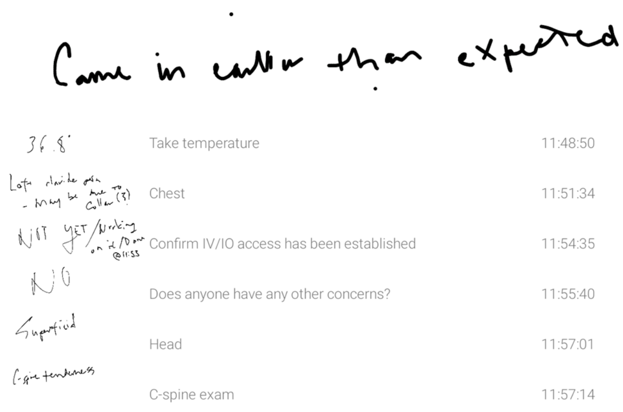

Figure 2: An image file from the digital checklist log showing handwritten notes taken during a resuscitation event.

errors. In two cases, participants reported they had used the checklist twice that day. The feedback data were organized in an excel sheet, including date of report, participant ID, type of trauma, feedback notes, corresponding system updates, and researcher's notes. If immediate system issues arose, we addressed them and provided a system update for continued use of the checklist during the study period. We later analyzed the feedback for trends in challenges with the system use and suggestions for improvement.

Data Analysis

DIGITAL LOG ANALYSIS

Using the excel sheet of transcribed logs, we made high level quantitative and qualitative observations about the checklist use. First, we analyzed the handwritten notes, computing where participants took notes. We then took a closer look at the notes, including the type of note (freeform, numerical, or numerical with attribute), as well as the nature of the handwritten notes, categorizing them into five high-level categories (patient values, physical assessment findings, pre-hospital information, task completion state and care plan). We also calculated the frequency of unchecked items. This analysis helped shape our understanding of how participants used the checklist.

PARTICIPANT FEEDBACK ANALYSIS

The feedback data from participants was unstructured because we did not want to limit their responses. This open-ended format allowed participants to provide thoughts and opinions on aspects of the system they found important, or issues that prevented them from achieving their goals. As we received the reports, we categorized the information into one of four categories: system issues, usability issues, improvement ideas, and other comments. First, we identified system issues that needed to be addressed, prioritized those items, and then made corresponding system updates to resolve them. We also created a list of usability issues and proposed improvements from participant feedback, prioritized these and implemented several changes. The more complex ideas were discussed without being addressed and we plan to include these modifications in future versions of the application.

Findings

This study provided insights about how participants used the various features of the digital checklist, challenges they faced, as well as ideas for how to improve the system.

Note Taking Feature

We found that participants took handwritten notes in all but one use case. We categorized these notes and

Participant Feedback

Participant 1: "*No issues, other than frustration at having unchecked boxes because the coordinator didn't perform all the steps.*"

Participant 2: "*I think an item should check itself if you insert numbers. For example, if you put in '100' for the Pulse ox value, I think it would be good to have it automatically check it. I put in numbers for all the vitals, and didn't realize that I hadn't checked the boxes until the very end.*"

Participant 2b: "*We currently cannot erase what we write in the free space at the top. I think it would be useful to have the option to erase there.*"

Participant 3: "*Didn't like that taking a note would auto check the box - would sometimes take a note but want to go back and check the box after the task was competed.*"

Table 2: Excerpts from participants' reports.

calculated their frequency: patient values (18), task completion state (15), physical assessment findings (9), pre-hospital information (5), and care plan (2). These notes were also categorized into freeform, numerical, or numerical with attributes (Table 1).

Participant Feedback and Design Ideas

Autochecking feature: A recurring theme in participants' reports was about an option to autocheck items when notes (handwritten or typed numerical) were taken (Table 2, Participant 2). In one of the design iterations, we added a numerical input for items that often had numerical notes associated with them (e.g., vital signs). One participant suggested that writing a numerical note meant that the task had been performed, so the item should be autochecked. Initially, the design included the autochecking feature for items for which a handwritten note was taken or a numerical note entered. However, another participant reported that autochecking of handwritten notes was not intuitive because taking a note did not necessarily imply task completion (Table 2, Participant 3). After discussing this feature with several participants, we decided to remove autochecking for handwritten notes, but continue enabling this feature for numerical values.

Erasing handwritten notes: Two participants commented on the ability for erasing handwritten notes (e.g., Table 2, Participant 2b). In instances where users could not erase or did not have time to erase whole words, notes were crossed out. One participant suggested a "strike-through" method to erase a note. We implemented an erase functionality for both margin notes and individual note boxes to improve the usability of note taking.

Editing existing notes: One participant described a note-taking scenario where they took a note for "lower extremities" while the team was assessing the front of the patient's leg. Later, when the team was performing the back exam, they examined the back of the leg and the participant wanted to add to the previously taken note, but the initial note got erased when adding was attempted. The participant explained that when editing a note, the original notes should repopulate the handwriting area.

Note-taking area: We placed a margin area at the top of the digital checklist (Figure 1) for handwritten notes to replicate the experience with paper checklists. One participant commented on this space being small but realized that screen space on a tablet is limited. He then proposed a design solution:

> "*Would it be possible to have a drop down option where if you press a little tab, the free space expands affording more room? When the user is done writing, he/she can press the tab again and the free space shrinks back to normal?*"

Typed note function: There are several items on the digital checklist where typed notes can be entered (e.g., "120/80" for blood pressure). One participant explained that typing the two-value note for blood pressure would be more efficient if the system could jump from the first number entered to the second number (diastolic to systolic). The blood pressure values, however, can include 2 or 3 digits, making it challenging to automatically determine when the first value entry is complete.

Challenges of Design In The Wild

Although we provided participants with a digital checklist and basic guidelines, the actual use and feedback were left unrestricted. One challenge we faced was the lack of data about system crashes, because we could not collect logs. These crashes would be simple to replicate in a simulation environment, but during the in-the-wild trial, every patient scenario is unique. Another challenge was that we were not present at the site when participants were using the checklist. Rather, we relied on participants' accounts of what occurred to diagnose errors and implement changes. In one situation, upon clarification, the participant sent a video screen capture of the error that caused the checklist crashing. Finally, participants used the checklist while shadowing actual team leaders. Because participants' input into the real workflow was limited, they would get frustrated when tasks were left incomplete, as one participant commented (Table 2, Participant 1). Despite these challenges, the in-the-wild design and evaluation approach was valuable because it provided us with a closer understanding of how the technology would be used in the actual safety- and time-critical setting of trauma resuscitation, rather than in a controlled usability-testing environment.

Discussion and Conclusion

By applying the in-the-wild approach, we were able to identify challenges of unstructured participant activity. The participants in this study were also researchers, allowing them to experience both sides of the design process. The rich and timely feedback from participants helped us identify directions for future digital checklist designs. As the participants used the checklist, they imagined features they wished they had. And, as they became more comfortable with the system, more advanced design ideas arose. For example, a lot of discussion surrounded the note taking functionality, showing the importance of this practice. Note taking areas should include features for erasing and editing existing notes, similar to how a paper medium would function. Given the limited screen space, an expand-and-collapse section for the main margin area at the top of the checklist may be better than a fixed one. To this end, continued feedback from participants as they use the checklist in more scenarios will be useful.

This was our first deployment of the digital checklist, resulting in several unexpected system issues. We were able to resolve these issues because the participants provided detailed reports after every checklist use, including the cases when the system crashed and participant data about the resuscitation were lost. Although we have obtained many insights about the system use in the wild, the most challenging aspect of the study was our inability to observe the system use in real time, making the participants' feedback even more critical to our work. We are now planning the next phase of our research—to deploy this digital checklist with actual physician leaders during real trauma resuscitations and further evaluate the system.

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