Supporting Information Management in ICU Rounding

A Novel Mobile System for Managing Patient-Centered Notes and Action-Items

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***Abstract*— Team rounds on patients in the hospital's intensive care unit (ICU) results in the generation of several paper-based and digital notes. Paper-based notes, although short-lived, act as translational artifacts that help organize and coordinate patient information and care. Maintaining double records of paper and digital notes can introduce several awareness and coordination problems such as contextually situating clinicians as to a patient's on-going care. Based on the design requirements derived from our fieldwork, we propose a new technology, PANI (Patient-centered Notes and Information Manager). PANI is a clinical tool that integrates the use of a mobile application, paper-based artifacts, and a wearable device (such as FitBit) in one system to support the management of notes and action-items that are generated throughout a typical ICU clinical shift. In this paper, we present the functional design of PANI and our preliminary findings of a participatory study that included 15 clinician participants.**

Keywords—information scrap; notes; task management; ICU rounding; clinical informatics; human-computer interaction.

I. INTRODUCTION

Rounds on patients are a structured, essential duty performed by the critical care team members in a hospital's intensive care unit (ICU) [1,2]. It typically involves a team of clinicians (physicians including faculty, residents/interns, fellows, and/or students, nursing, respiratory therapists, and pharmacists) meeting either in a conference room or outside the patient room in the ICU hallways (Figure 1). During rounds, the clinicians present a patient's condition from the previous day. The team then collaboratively works to identify a 24-hr plan of action comprised of patient-centered tasks/action-items, which can change as the day progresses. The action-items can include medical orders (e.g., laboratory tests or administering medication), a collection and summarization of patient physiological measures, a follow-up/consultation with specialists, and so on. Typically, an assigned critical care team member completes the list of action-items. For instance, residents play a key role in placing medical orders and caring for the patient, nurses implement the orders and collect results, and the critical care fellow completes assigned medical procedures. Common to university hospitals, rounds also involve an educational component with the attending staff or fellow who teaches and distributes significant clinical knowledge to the residents and medical students.

Emerging health information technologies, such as, electronic medical record (EMR) and computerized physician order entry (CPOE) systems provide support to ICU members with support in managing some action-items, such as medical orders from the previous rounds. As part of a secure and unified workflow, medical orders management includes the use of standardized clinical documentation. Although hospitals have stationary and/or mobile workstations with EMR and CPOE facilitating the completion of action-items, paper-based artifacts are also commonly used as an external aid in managing information through the note-making process [3].

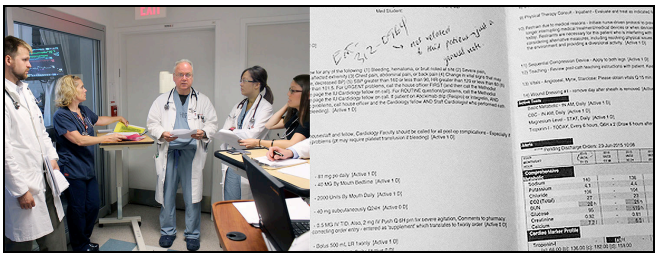

Figure 1. (Left) ICU team gathers for morning rounds to exhange patient information/condition. (Right) Sample paper artifact referred to as rounding checklist, used by the critical care team as external aid during ICU rounding.

We refer to the content of the notes written on paper-based artifacts (as a part of ICU rounding) as "information scrap notes" (ISN). (See Figures 1 and 2.) ISN are personal/informal notes made every day before, during, and after ICU rounding. They do not replace the standardized, digital notes documented every 24 hours as a part of the patient EMR. ISN aid in externally distributing information (usually transferred as a part of digital notes) that has to be remembered by the critical care team members. Paper-based artifacts offer affordances such as manipulability and portability [4]. Hence, ISN serve as an efficient tool aiding in scribbling notes without losing track of what is being said during a rounding conversation.

A typical setup in hospitals includes an EMR and CPOE that does not replace paper-based notes generated as a part of ICU rounding. The contents of the ISN are usually modified and transferred/converted into digital form. For instance, ISN with the content "☐ chest x-ray" scribbled by a resident on a rounding checklist (for patient X), represents an action-item to create a medical order requesting a chest x-ray. The resident then transfers this action-item as a medical order for the patient using the CPOE. Following this, the content in the ISN is modified to "☑ chest x-ray" signifying its completion. Consequently, a **double record** consisting of redundant information exists both in paper (as a checked action-item) and digitally (as a medical order). Having double records has the potential to cause several awareness and coordination problems [5], such as contextually situating clinicians related to a

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patient's on-going care. For example, a resident may be forced to physically find a nurse and initiate a face-to-face conversation for changing a patient's medication dosage. This practice of finding the nurse becomes difficult if the nurse is not present close to the patient's room or at the nursing station.

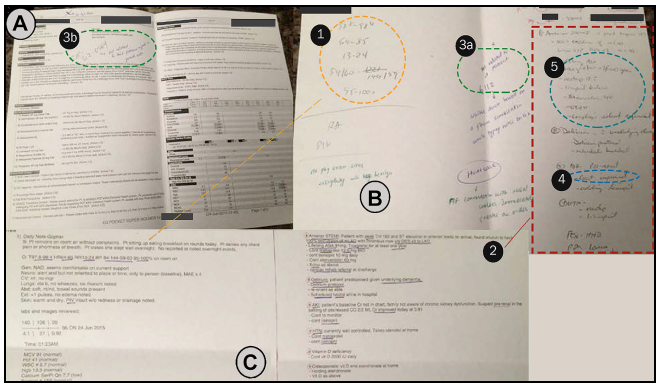

Figure 2. ISN lifecycle from original paper-based artifact (A) to ISN written on the back side of the paper artifact (B) to translation of some of the written notes into digital form (C). (1) depicts the patient's subjective, vital information written before rounding from EMR and paper artifact (A). This information will act as an external aid during rounding presentation and is later translated with exact numbers in the digital progress note. (2) depicts the assessment plan for the day written berfore rounding, used as an external aid to present during rounding, and serves as a prime to jog memory while translating the assessment plan as a part of the digital progress note (C). (4) depicts the reminder to self to consult with a specialist, (5) denotes the action-items which are created as medical orders in addition to being translated as a part of the digital progress note. (3a) and (3b) denote information to self that may/ may not be related to the patient.

II. Problem Space

To more accurately identify and understand the clinical problem space and how paper and electronic patient records are used, we conducted an informal preliminary field study prior to the design study, which included 20 hours of observation of an ICU team before, during, and after rounding. Observations were followed by semi-structured interviews, which led us to probe further, where we performed task-centric, artifact-centric, location-centric, and hand-off centric shadowing and contextual inquiries of residents over a period of 60 hours. Findings from the field study (reviewed by 2 lead ICU physicians) helped us understand the ISN life cycle, and action-item generation and management. Findings also allowed us to identify the following ISN content types and their usage in the ICU.

ISN content types include: (1) action-items, (2) pointers that help jog one's memory, (3) reminders that one wants to follow-up or consult with, and (4) reminder notes that serve as a message/info to self. These findings overlap with other content types recognized in office-work domains [6]. ISN content usages include: (1) type out post-rounding action-items as orders/progress notes using the EMR, (2) consult specialists/sub-specialists on topics raised during rounding, (3) update team on general patient care based on the result of action-items, (4) hand-off to fellow members during change-over, and (5) remember to perform an activity (e.g., calling someone) at a later time.

As noted above, ISN are personal notes that are not typically shared. Thus, there is a lack of synchronization between both the paper-based and digital representations [7]. For instance, while the resident can check-off an action-item on his/her personal ISN (e.g., regarding consulting a specialist about a patient's condition), the others on the team are not necessarily notified that the action-item has been completed. This forces some of the members to update the others through external communication means (e.g., phone). Since not all members are always reachable, the resident will need to communicate the information in a timely manner, thus adding to the existing cognitive load often experienced in the ICU [8]. To address this first problem, we envision a smart system where the resident can notify other clinicians as required, enhancing the ability for everyone to remain mobile.

ISN have a short life, typically lasting as long as the critical care team member's shift. Also, they are not archived, but rather discarded at the end of the shift. Hence, potential information recorded in ISN can be lost. Further, incomplete action-items from the ISN are often transferred as change-over occurs within the ICU team. This requires re-writing content onto a standardized paper-based sign-out sheet, which can again result in potential loss of information. Further, boundaries between the tasks and roles are not tightly drawn [5]. For instance, a nurse may suggest a medication dosage (through a verbal order) and complete the administration even before the resident has formally signed her request on the EMR/CPOE. To address the second problem, we envision a system that allows creating and forwarding action-items on a centralized server. According to this configuration, everyone can see what everyone else should complete by the end of the day.

Previous studies indicate that the priorities of the action-items formed by the team while rounding are at times implied or not prioritized as intended [9]. For instance, the nurse may not receive a medical order created by a resident that is prioritized as "urgent" as an "urgent" order. This is because he/she may be attending other patients and/or was not notified immediately. To address the third problem, our proposed solution allows ICU clinicians to notify the recipient based on the priority of an action-item. For instance, a resident can create an action-item with high priority and notify the nurse to take immediate action. Thus, the nurse will receive a visual and tactile notification regardless of location, as soon as the action-item is assigned. In sum, the completion of all the action-items requires an awareness of a patients' condition and other team member's contribution to the plan of action for the day. Equally significant and impactful to a patient's care and recovery is clear and regular communication and collaboration between the critical care team members [3,8,10].

To mitigate these three problems, we propose a patient-centered notes and information manager, we refer to as PANI (Patient-centered Notes and Information Manager).

III. PANI Concept

PANI is a clinical tool that integrates the use of a mobile application, paper-based artifacts, and a wearable device (such as FitBit) in one system to support the management of notes and action-items that are generated throughout the typical ICU clinical shift. (Figure 3). PANI comprises three parts: (1) a easy-to-carry clipboard that fits in a doctor's pocket, allowing traditional paper sheets to be attached for facilitating easy note-taking, (2) the mobile device application that is accessed from a detatchable smartphone clipped to the clipboard, and (3) a

wearable device, such as FitBit configured and paired with the mobile application to provide tactile "silent" notifications for personal reminder alerts. The components of PANI can be detatched and used seperately or used together as a whole to integrate into exiting ICU rounding workflow.

Figure 3. Proposed concept of PANI that supports ICU information management.

The mobile application module of PANI provides the following features: (1) scrollable list of action-items specific to the role of the user, (2) visual depiction of the flow of action-items between the critical care team members as they are created, assigned, forwarded and completed, (3) ability to setup visual and tactile (through FitBit) personal reminder alerts to check on something at a later time of the day, (4) visual notifications of action-items that are less intrusive by means of prioritization (high, normal, low) and time (immediate or negotiated [11]), and (5) linkage to medical intervention results from EMR (e.g., labs, x-rays), allowing secure and ubiquitous access to patient-centered data (Figure 4).

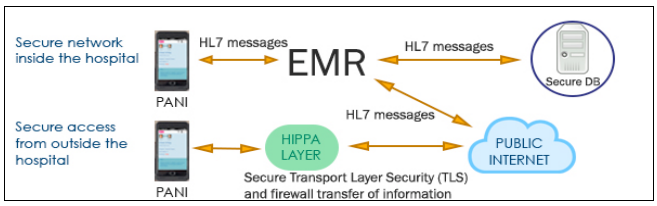

Figure 4. Information architecture for the mobile application module of PANI. The Health Insurance Portability and Accountability Act (HIPAA) ensures that privacy rules are maintained in providing federal protections for identifiable ICU patients.

IV. Design Study

A. Method and Participants

To explore the feasibility of PANI and to enhance our understanding of how such a device would integrate into ICU rounding and overall workflow, we conducted a formal qualitative evaluation. Methods included semi-structured interviews and discussions on the perceived usefulness and feasibility of PANI in ICU rounding workflow. The goal of the study was to obtain feedback on the concept design and its modules. This also included an evaluation of two design versions of the mobile application. (See Figure 5 for sample screens of the PANI interfaces.) During the study, we introduced the concept of PANI to each clinician and discussed perceived usefulness of each of the modules and its features.

Clinical participants included a convenience sample of 5 residents (R1-5) on their ICU rotation and 10 ICU nurses (N1-10). A list of potential volunteers was provided by one of the lead ICU physicians working in the general ICU of Eskenazi Health Hospital, Indianapolis, IN. From this list, volunteers were invited to participate.

B. Findings

Clinical participants reported PANI as being a very useful tool for ICU rounding and overall clinical workflow. The functionality of PANI that enables the creation and assignment of action-items among team members was noted positively:

"I really like how I can assign an action-item to a nurse and notify her that it is important; along with hearing back from her before she/he leaves for the day. That way, I don't have to go looking for her/him in person or make a phone call." – R1

"With the current setup, I have to click through several screens on a computer at the nursing station for me to know what task was assigned to me. The orders are not arranged by patient details. As a result, I have to go through an entire list to find my patient and then go look at the corresponding order. Also, this device or application makes it so easy for me to notify the doctor when the results are ready. This is pretty cool." – N1

The feature to setup personal reminder alerts as tactile "silent alarms" using FitBit was perceived as very useful:

"It is so much easier for me to setup an alarm using the digital application of PANI. Because I can forget about trying to remember, I can focus on other things. I like how the FitBit vibrates and I see a visual display on my phone. I think I should be able to recollect why I set this alarm even if my phone is in my pocket – and I don't necessarily need to look at it when the FitBit starts vibrating. Also, since there is no sound, I don't think I will be disturbing others around me." – R3

"I like how PANI does not depend on the vibrations of the phone. I can see myself putting my phone in my pocket. That is, sometimes I never notice if my phone is vibrating. This would usually mean I missed a message or phone call." – R5

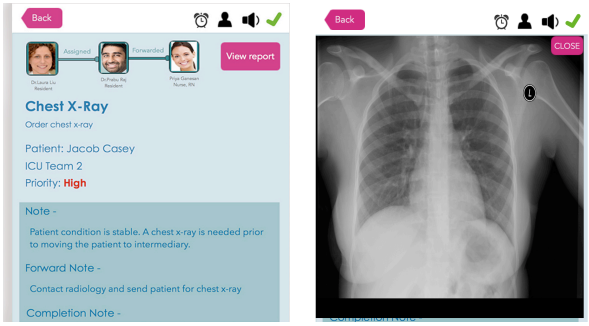

Figure 5. Sample interface of the PANI mobile application module. (L) Action-items page from design 1: clinicians reviewing this page see a visual path/flow of action-items as its status is updated. (R) Clinicians can view the chest x-ray by taping on the view report button when the results have been uploaded to the EMR.

The color-coded notification feature (displaying information with action-item updates and results from the EMR as a completed action-item) was perceived as very useful:

"The application is intuitive in letting me know that something colored red is urgent, orange, maybe normal, and yellow is of low priority. I can determine when the nurse completed a high priority action-item when I see the notification. For example, as with this session, I can detach my phone from the clipboard and actually clip it to the top of my workstation when I am busy using the EMR. It is really nice that I can see a link to the radiology image of the patient. I see

this feature helping me share the image with the family members next time I visit the patient." – R4

Finally, participants proposed the need for a corresponding desktop version of the mobile application that allows them to begin a note or action-item, which can later be resumed using their workstation. They argued that the short notes that they create using PANI can be edited with ease, which they believed would reduce cognitive effort as well as serve as an external memory aid. Participants preferred retaining sheets of paper on the clipboard as opposed to having a stylus input on the phone to allow for quick note making, especially during a phone conversation. However, they suggested having audio input to call out quick notes at instances other than during a phone conversation. They also preferred carrying rounding sheets with patient details for quick hands-on information as opposed to having a digital tool that helped them go through multiple screens to find the patient data of interest during rounding.

Directed by prior research in mobile health and participatory design methods [5,12,13] and our study findings, we propose the following design principles for PANI:

(1) Visibility: a centralized platform offered by the mobile application that lets all clinicians see what everyone else is working on with respect to action-items and shared notes.

(2) Module-based use: ability to support different mediums/modules of usage based on the types of content from the ISN. For instance, the system should allow: (a) creation of shared action-items and digital notes both on mobile and its corresponding desktop version, (b) scribblings of quick paper notes that the user can later digitize (by taking a picture or typing out), and (c) setting up personal self-reminder alarms. All representations of information should be usable separately, without changes to the original purpose/use.

(3) Recognizability: to support easy identification of any set of action-items based on any patient or the priority of action-items. The clinician should have the ability to know the status of an action-item assigned to someone else through user-controlled notifications.

(4) Shared representation: ability to provide different representations of action-items and/or notes shared on the centralized platform in a balanced manner based on the role of the clinician. For instance, although residents and nurses see the same underlying information about action-items, the visual representation and functionality of the shared information will be different to achieve coordination [12].

(5) Ubiquity: ability to create and assign an action-item to someone during and post rounding process ubiquitously, irrespective of physical presence of the recipient.

(6) Connectibility: ability to convert an action-item as an EMR/CPOE medical order and to display the results from a medical intervention (e.g., radiology or labs) on a mobile device.

V. Conclusion and Future Work

Previous studies have identified paper to play a significant role in daily activities in multiple domains [4] in addition to acting as a translational artifact that aids in efficient collaboration [3]. As such, the concept design of PANI (a mobile application prototype) was developed based on initial exploratory fieldwork. Following the design of PANI, a formal participatory design study was conducted involving semi-structured interviews and discussions on its perceived usefulness and feasibility in ICU rounding workflow.

The primary goal of PANI is to explore the inclusion of an ICU tool that combines different modalities: paper, digital (mobile and desktop), and a wearable device. This includes an attempt to situate everyone contextually with respect to the progress of the patient. As such, PANI uses the tactile feedback provided by an existing wearable device as opposed to the tactile feedback provided by the mobile device. This is because often times the critical care team members reported having their phones in their pocket, thereby missing a vibrating alert. The form factor of PANI includes a module-based structure where the paper and mobile digital artifacts can be assembled together or used as separate. Thus, PANI is capable of providing affordances such as flexibility, portability, and accessibility, much similar to paper-based artifacts by themselves [4].

In summary, PANI provides ICU clinicians with a tool to break down their original note making practice based on the module of interest. For instance, clinicians can create and share quick action-items with the team using the mobile application. They can continue to use paper-based artifacts for scribbling quick and immediate notes based on the urgency of the situation. Further, ICU clinicians can take advantage of a FitBit device to setup personal alerts reminding them at appropriate times to perform an activity.

While we are yet to test an interactive prototype of PANI in the field, our initial findings are promising. Future work on PANI will focus on submitting it to usability testing using several clinical scenarios in simulated ICU environments to inform further design refinements.

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