Better managing technology-mediated interruptions in the ICU: Examining the role of patient information for improving text message notifications

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Abstract

Previous research has identified the need for managing wanted and unwanted interruptions from technology-mediated notifications (TMN) in the intensive care units (ICUs). Current solutions are focused on mobile, asynchronous and context-aware mechanisms that consider a minimal number of factors (location and activity of the receiver). These factors are insufficient for a receiver to effectively decide on whether or not to interrupt their ongoing activities to immediately respond to a TMN. We propose a mobile device solution, known as "patient-enhanced notifications" that presents a preview of TMN with additional patient information. A study comprising of user evaluations and interview sessions helped ascertain that patient vital signs coupled with the actual text message assisted receiving ICU providers in deciding on when to respond to the TMN. We conclude that patient-enhanced notifications has the potential to help ICU clinicians better manage interruptions generated from mobile devices.

Introduction

Hospital intensive care units (ICUs) are intensely complicated environments characterized by a high degree of communication and collaboration between patient-care team members.[1,2,3] Team members must often re-align and re-orient their knowledge about the patient, tasks, and goals to ensure high-quality care.[3] Consequently, the need for timely communication of patient information often result in team members interrupting and being interrupted more frequently in the ICU.[4,5] Information and communication technologies (ICT), such as, patient electronic medical records (EMR), pagers, smartphones create new opportunities for communication and dynamic updates for patient care; however, at the same time, they also introduce potential work interruptions through technology-mediated notifications (TMN) such as alarms, alerts, and pop-up messages.[4,6,7] Gill and colleagues[8] argue that a growth in mobile healthcare-related applications could lead to their increased use while communicating, collaborating, and disseminating tasks between healthcare providers. Although these technologies increase the ability to communicate and collaborate, they also introduce the possibility of someone being unnecessarily interrupted through a phone call or a text message.[9] For instance, the introduction of wireless cellphones can lead to increased nurse-physician communication, but at the same time, cellphones can also interrupt the nurse's or physician's work. Further, the process involved with deciding whether to respond or to avoid the phone call can increase the already high cognitive load often experienced by ICU providers.[10]

Sasangohar and colleagues[11] define interruptions as "externally or internally generated, unexpected events that may cause a break in the primary task, diverting attention to a related or unrelated secondary task, which can have both negative and positive effects on the interrupter's or the interruptee's main task." (p. 3) Interruptions have also been called distractions, breaks-in-task, and disruptions.[6,7,12,13,14] Several workflow-based studies in healthcare associate interruptions with negative impact on human cognition often leading to medical errors.[15,16] For instance, 43% of medication errors are attributed to interruptions,[16] and the Institute of Medicine (IOM) identifies interruptions as a potential factor contributing to medical errors.[17] Consequently, existing research has focused on interruptions and factors that make them disruptive,[9,15,18,19] often suggesting a set of design implications on when people can be interrupted.[4,5,25,26,27,28] Although there is a predominantly negative view of interruptions caused by TMN, some studies acknowledge the important information a TMN may carry.[9,13] Some examples of positive effects identified include contributing to increased safety, improvements in patient comfort, and increased accuracy.[13] Because interruptions can be wanted or unwanted by a receiving ICU provider at any moment, we need to develop approaches for interruption management that increases the usefulness of the interruptions while reducing the negative effects on cognitive load.

Edwards and colleagues[9] suggest taking advantage of properly designed asynchronous ICT that can mediate non-urgent interruptions, and divert a phone call to more opportune times. In this paper, we report on a study examining a potential asynchronous solution that involves presenting patient information in addition to the actual text message, to help the individual receiving the text to decide when to respond to a TMN. In the remaining portions of the paper, we refer to the person performing an action leading to TMN as the "interrupter" or "sender", and the person receiving the TMN as the "interrupted" or "receiver". Our research investigation sought to investigate the following research question: "Would patient information such as vital signs in conjunction with a text message be useful in helping ICU providers decide whether or not to immediately interrupt their work to respond to a TMN?"

This paper is organized as follows: First, we review existing research on managing interruptions in the ICU. Second, we briefly describe our work on examining interruptions at an ICU site, including the identification of other additional patient information that is of interest to providers while responding to TMN. Third, we walk you through our study design methodology and results. Lastly, the paper discusses our findings and how our approach has the potential to help receivers better manage interruptions from TMN in the ICU.

Background

Researchers have extensively examined how people manage interruptions.[20,21,22,23] For instance, Harr and Captelinin[24] discuss the impact caused by the occurrence of an interruption beyond the interrupted activity through the creation of a "ripple effect". This research suggests considering the social context in understanding peoples' strategies for interruption management. On the other hand, some studies suggest considering the cognitive context as well while managing interruptions.[25,26] Other studies argue that effective interruption management can be achieved through increased awareness among the colleagues.[4,27] For instance, the aspect of "awareness related to action" can be used to reduce unwanted interruptions or facilitate wanted interruptions. The strategies people rely on to: (1) make their work visible to their colleagues, and (2) monitor what colleagues are doing, can help promote awareness, subsequently helping decide whether an interruption is wanted or unwanted at the moment.

Grandhi and Jones[28] suggest considering "relational context" (such as, the content and urgency of interruption, interrupter-interrupted relationship and so on) while understanding and managing interruptions. The authors of this paper discuss the notion of how the receiver can associate a perceived cost and value to a TMN while deciding how to respond. Two interruption management paradigms are examined: (1) the ***impact reduction paradigm***, which seeks to reduce the cost induced by an interruption by using techniques that either **prevent** or **block** TMN, and (2) the ***interruption value paradigm***, which allows the receiver to evaluate an interruption based on its perceived cost and utility from a **preview** of useful information from the TMN.

Figure 1. Preview of a text message notification with

Some recent innovations in ICT, such as, reminders[31] and context-aware architecture,[28,31,33] have been proposed to reduce interruptions through asynchronous communication. These systems, however, consider a limited number of factors from the receiver's context. For instance, the communication service proposed by Dahl[31] allows hospital workers to leave digital messages at relevant physical locations (such as patient bedside), so that the intended colleague can retrieve them at a later time. This approach is based on the assumption that hospital workers move between various locations mainly out of work priorities. However, other factors such as social activity at the location, content and urgency of each message, and the relationship of the timeliness of message reception to patient's condition are not considered.

Previous research has focused primarily on identifying techniques for blocking interruptions in the ICU. For instance, researchers reported reduced interruptions with the introduction of an external signage[29] or intervention that blocks face-face communication at selected locations,[30] while others considered an awareness display that presents information to the interrupter about the workload currently experienced by the interruptee.[28] These techniques, however, focus on the idea that both the sender and receiver are physically co-located and do not provide much assistance when they are geographically separated from each other. Further, these techniques require the receiver to remain within the same space as the interrupter when she does not want to be interrupted.

In this paper, we propose a solution that "adapts" the interruption value paradigm to **include patient information** for aiding "receiving" ICU providers, while improving their ability to manage interruptions from TMN with reduced cognitive load. This requires providing a preview of patient information (such as vital signs) along with the actual message to provide more context to the receiver while making sense and deciding to interrupt an ongoing activity (Figure 1). In the next section, we briefly describe the field observations and follow-up focus group sessions, both of which were IRB approved and helped in the development of this approach.

Examining Interruptions at an ICU Site

Observations: We performed ethnographic field observation including contextual inquiry[34] (of two ICU teams) in a 16-bed medical ICU used to monitor and treat critically ill patients. The observational notes were transcribed and coded using the Locales Framework.[35] We viewed the situated nature of ICU work using the idea of dynamic social worlds. This helped us focus on the interaction at hand. We collaborated with two expert ICU physicians who helped validate our data interpretations and findings. We encourage readers to refer to previous work on understanding and designing for collaborative, sociotechnical environments.[35,36]

The study site is comprised of electronic information sources such as EMR, patient charting and order notification system, bedside physiological monitors and infusion pumps. The existing technology systems supporting communication between the providers at the study site included electronic resources such as: (1) landline telephones (placed outside patient rooms, at nursing stations and conference rooms), (2) hospital-owned mobile ASCOM cellphones (which does not provide any information regarding the caller when a phone call is received), and (3) pagers (occasionally used for communication between the providers). The pagers are only used to convey callback phone numbers and notifications when a patient needs immediate attention (such as room number of a patient).

Below, we present an example involving a synchronous communication between a nurse and a resident regarding a patient. A nurse (N), who is currently at the nursing station, calls the patient's resident (R) using cellphone. R, who is currently busy talking with his colleague regarding another critically ill patient, does not know for certain the urgency of the phone call compared to the ongoing face-face conversation. Since R cannot determine who is calling, he interrupts his face-face conversation and answers the call. We report an extract of this conversation.

> N: Mr. S from 166 has positive blood culture for staph aureus.
>
> R: What are his current vitals?
>
> N: He has fever with temperature 101, blood pressure is 120 over 90, heart rate 65, respiratory rate is 11, and blood oxygen is 95% on ventilator.
>
> R: All right, I will sign orders to start vancomycin and serial blood cultures.
>
> N: Ok.

R had to **interrupt** his ongoing activity (face-face conversation with colleague) to respond to a phone call because he did not know who was calling him and the importance of the call. R was able to understand the condition of the patient and the urgency of the information conveyed based on additional patient information (such as current vital signs) provided to him by the nurse.

In an example of asynchronous communication – a resident who is participating in the morning rounds with his team receives a page message "0119865862". The resident understands that the message is a callback number. Since he does not know the actual patient information that will be conveyed in the phone call, and since he does not know how urgent it is to call back, he steps away from the team to call the number. This results in the resident **interrupting** his current activity and missing some of the morning rounds discussion.

If the resident in the above example had received a visual cue containing the lab result and vital signs from the nurse before initiating a phone call, this would have been less disruptive. These cues will improve the contextual awareness and also provide implicit information on the priority with which the resident had to respond. For instance, seeing an abnormal temperature, heart rate, blood oxygen saturation in addition to the lab results can indicate to the resident that the patient is having an inflammatory sepsis response. That is, the extra patient-centric information such as vital signs that were discussed during the phone call could have been provided beforehand along with the actual message to expedite the resident's understanding and decision-making of next steps. Further, the resident would have had more freedom in planning and strategizing when to interrupt an ongoing activity while responding.

Focus Group: We conducted a focus group session (FG1) with five ICU providers to understand the type of patient information that receiving providers are interested in while deciding how they responded to TMN. This was followed by another focus group session (FG2) with two ICU providers and five user experience designers to create a design template that will be presented as preview text message notifications (Figure 2), including fictitious scenarios and information content for the sample text messages used to evaluate our designed solution.

In general, the information shared between providers include: lab/radiology results, patient's response to medication, procedure completion and corresponding patient's condition, and follow-up/consult with a specialist. One of the findings from FG1 also pointed to other additional details that can persuade the receiver to pay more attention while deciding to respond to a TMN. For instance, the information perceived by the sender based on the patient's current condition, i.e., the indirect information perceived from the patient is often used to indicate the "priority/urgency of the message" during communication. FG1 also generated a set of sample text messages that can be shared between ICU providers. Several benefits and challenges to multiple versions of design templates were discussed and clarified in FG2. The design considerations from FG2 included (Figure 2): (1) explicitly depicting the importance of a message with respect to patient's current condition by coloring the background of the preview notification (red: high; yellow: low; grey: none), (2) explicit color-coding of content to direct the attention of provider to important information that is abnormal or needs attention (red), (3) details on the patient and the sender of the message, and (4) placement of the patient's current vital signs and the contents of the actual message. The focus group sessions contributed to the generation of fictitious scenarios and sample messages that can be conveyed as a text message notification.

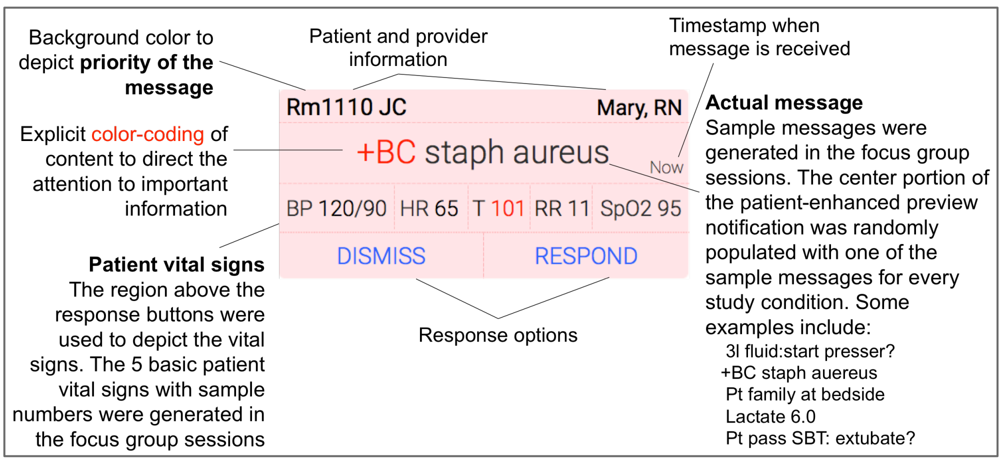

Figure 2. Patient-enhanced notification depicting the actual message (+BC staph aureus) along with additional information such a vital signs and priority of the message (red background color). Content is explicitly color-coded to direct attention to parts of the actual message (+BC) and vital signs (101).

Based on our observations and focus groups, we propose a solution that involves presenting additional information obtained directly (from EMR) and indirectly (such as nurse's perception) from the patient, along with the actual message as a "**preview text message"** to improve the receiver's understanding and awareness of the patient, eventually contributing to making rapid decisions on when to respond to text message notifications. We refer to this "preview text message" notification with additional information as "**patient-enhanced notifications**." The remainder of the paper describes the study design and our findings from an initial evaluation of the patient-enhanced notifications.

Study Design

Participants: Twelve ICU providers from the same study site as our fieldwork and focus group sessions participated in this study. The participants of the study are not the same as those who participated in the focus group sessions. The participant included: residents (P1, P2), nurse practitioners (P3, P4), fellows (P5, P6), registered nurses (P7–11), and staff nurse (P12).

Study Procedure: The study consisted of two activities: an evaluation of the patient-enhanced notification and an interview.

Evaluation session: This session was conducted in a quiet conference room where participants were required to use a web-browser (on a workstation) to evaluate the design of patient notifications. The evaluation required each participant to view a fictitious scenario along with an image of a patient notification (Figure 3). Participants did not receive any instruction manual explaining the design of the patient notifications.

Participants responded to a set of multiple-choice questions. The multiple-choice questions included: (1) How would you react to this notification message? The response choices for this question included immediately, respond later, or do nothing, (2) When do you prefer receiving this notification? The response options for the questions were chosen based on existing research[9,27,41], where, participants were asked to indicate whether a particular message in a given situation should be delivered immediately or at a future scheduled time. This session included a within-subjects design that required all the participants to respond to all the multiple-choice questions based on all the fictitious scenarios presented along with images of all text message notifications (Figure 3). All participants played the role of receiver of text messages. All the participants also rated their perceived urgency of each message on a scale from 1–10.

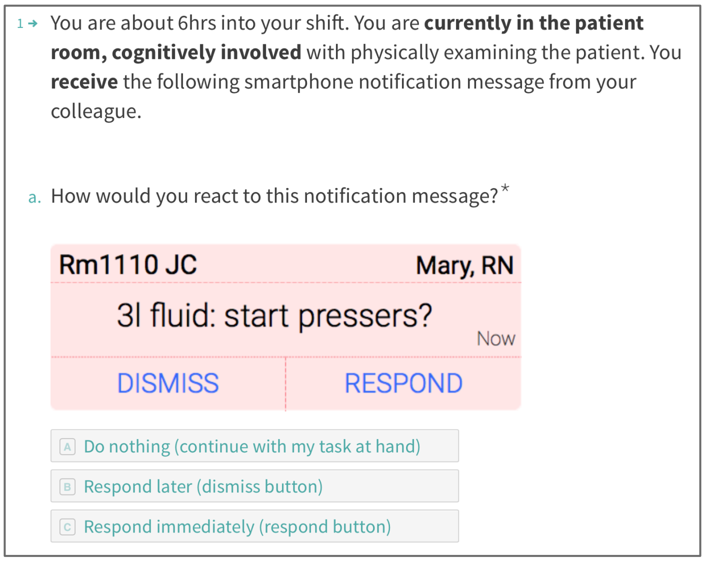

Figure 3. Screenshot of what the participants saw while completing the evaluation session

We utilized two scenarios that required the participants to imagine a receiver's situation while receiving a text message: (1) high cognitive load and present in patient room and, (2) normal cognitive load and in cafeteria. For instance, a provider playing the role of a receiver was presented a scenario and image as in Figure 3. The participant was then asked to report on when he/she will respond (immediately vs. later vs. do nothing). We presented the image of only one message at a time to examine the initial reaction of providers to the additional information in the patient-enhanced notifications (tested through the study conditions described below).

Study conditions: We varied the additional information that can be shared along with the actual text message to assess their value of particular type of additional information. We varied the order that the study conditions were presented between participants to avoid order effects. This study focused on providing the following four levels of additional information in text messages:

(1) None: In this condition, providers saw only the message with no additional information. The background of the text message was colored grey.

(2) Priority: This condition provided additional information such as the priority associated with the message. The levels of this condition included: Low and High. Explicit color-coding was used to depict priority information. For instance, the background of text messages was colored red or yellow to depict urgency of the message as high or low respectively.

(3) Vitals: This condition provided additional information on patient vital signs such as heart rate, blood pressure, temperature, respiratory rate, and blood oxygen content. The levels in this condition included: With and Without. The patient vital signs were again explicitly color-coded with red color to indicate abnormal values.

(4) Combination of priority and vitals: This condition included a combination of conditions 2 and 3 (Low vs. High and With vs. Without). All the participants were provided with the same study conditions, in a randomized order.

Data collection and analysis: Participants responded to questions administered through the TypeForm[1] website. The TypeForm website has a backend database tool for collecting participant responses**.** Quantitative data was analyzed using SPSS v.21. Participant responses to the multiple-choice questions were coded for performing descriptive and inferential analysis (1 = respond immediately, 2 = respond later, 3 = do nothing). We explored the receiver's willingness to respond immediately to a message with different types of additional information. Friedman's test[37] with the additional information such as: (1) priority (low vs. high), (2) inclusion of vital signs (with vs. without), (3) combination of both (Priority x Vitals), (4) perceived urgency of message (1 – 10), (5) the 2 scenarios, (6) designation of the participant (doctor vs. nurse), and (7) message viewing order (1 – 10) was used to examine the receiver's preferences for responding to text messages (immediately vs. later vs. do nothing). The rated urgency of these messages tended to be of low variance across the raters and did not cause confusion (Figure 4).

Interview session: The interview session occurred at the end of every evaluation session. In this session, all the participants responded to demographics-related questions and open-ended debriefing interview questions. The open-ended questions asked about: (1) the overall experience interacting with the designed text message notifications, (2) benefits of additional information while understanding and improving patient-situation awareness, and (3) how the additional information provided along with the actual text message aids in deciding when and how to respond to a text message alert or notification.

Data collection and analysis: Participant responses to the interview questions were audio-recorded and later transcribed for analysis. Qualitative data was coded and analyzed using ATLAS.ti. The post-evaluation interview session provided more information on how the additional information provided along with the actual message aid in deciding when and how to respond to a text message alert or notification. We report themes emerging from the coding of participants responses. Participant responses were also coded to identify suggestions that we used to help us provide some design suggestions for the patient notifications (Table 1).

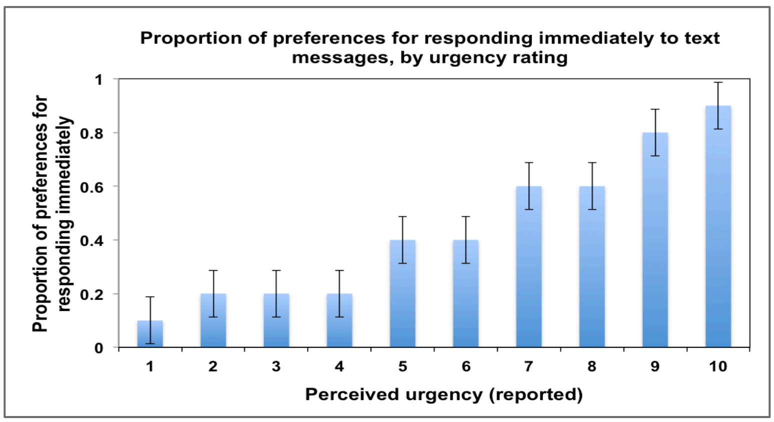

Figure 4. Proportion of preferences for responding immediately to text messages, by urgency rating

Results

Quantitative

There was no significant difference among providers in perceptions of how important it is to respond immediately while responding to messages with and without additional priority information ($Z = –1.630$, $p = .103$). Specific to messages that had additional priority information provided as high or low, providers preferred responding to text messages immediately ($Z = –3.503$, $p = .04$) if the priority of the message was depicted as high ($M_{High} = 67.19\%$) as compared with those depicted as low ($M_{Low} = 32.81\%$). No significant difference in response preferences was noticed based on the scenarios, or the designation of the participant (doctor vs. nurse). Providers preferred responding to messages immediately ($Z = –3.645$, $p = .037$) if vital signs were included ($M = 60\%$) as opposed to not including the vital signs ($M = 40\%$) with the actual message. A more detailed exploration of the interaction between priority (high vs. low) and patient vital signs (with vs. without) demonstrates that the presence of patient vital signs coupled with priority of the message affected provider's preferences in responding immediately to text messages (χ^2 (3) = 9.510, $p = .023$; Figure 5).

That is, providers preferred interrupting their ongoing activity to respond to text messages based on the priority explicitly conveyed through the background color, and implicitly perceived from the patient vital signs. For instance, receivers interrupted themselves less often for low priority as opposed to high priority messages when they knew the patient vital signs. On the contrary, they had similar preferences for immediate interruption for messages with no vital signs irrespective of the priority of the message. Overall, their preference was also backed by their perception of the urgency with which they had to respond based on the contents of the actual message in relation to vital signs.

[1] http://www.typeform.com

Qualitative results

***Color-coding*:** Providers found it easy to rapidly understand and perceive the information conveyed through colors in patient notifications. For instance, P5 noted, "*if I see something colored red, I automatically think it is abnormal. I was able to quickly understand that a vital sign is abnormal. Although I don't really need the coloring, I know what is normal and abnormal. I think the color will help me improve my speed with which I perceive the information presented. This can be very helpful when all I have to do is glance at the phone while I am in the middle of something.*"

Using patient vital signs: Providers reported patient vital signs as important information that they can use to rapidly understand a patient's condition from the message. For instance, P2 noted, "*the first thing I want to know when a patient's lab result is abnormal is his current vitals. Instead of trying to look into EMR or call the nurse, it will greatly save me time and effort if I can just glance at my device and see the message and vitals together. This will help me to quickly determine what has to be done next, do I respond to the message at the moment or continue with whatever I was doing.*"

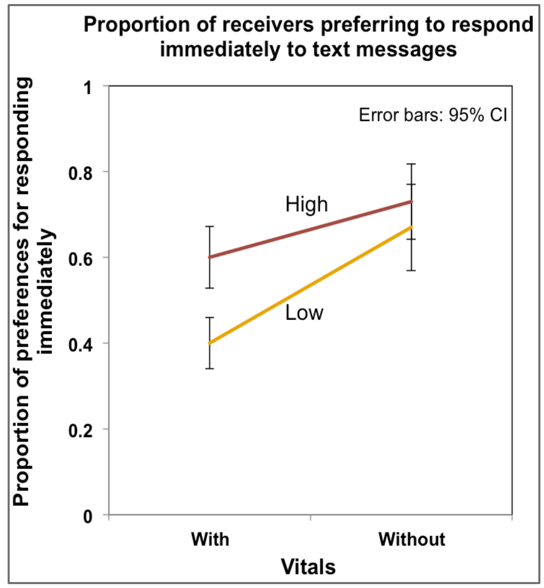

Figure 5. Proportion of preferences for responding immediately to text messages by patient vital signs and priority conditions

Providers reported glancing at patient vital signs to rapidly determine the time they had to respond to the message. For instance, P1 noted, "*if I am in the middle of rounds and if I receive a message with say a lab result and current vital signs, then I will be able to quickly understand the patient's current condition and how it relates to the lab result, what has to be done and when. If it is something important and needs immediate attention, then I can step away from rounds, otherwise I can respond later to the message. However, I am concerned if I will remember to respond later, you know what I mean?*" (this has been addressed as a design suggestion in Table 1)

Explicitly stating information on the urgency of a message shared: Providers reported not paying attention to the background color of patient notifications used to explicitly indicate the priority of the message. For instance, P1 noted, "*the patient vital signs are enough for me to know how important the message is. Besides, I might think a message is not really important while a nurse might consider the same message as really important. This is probably why I never noticed the background color of the messages. This might be useful if I see a series of text messages all together. That way I can differentiate which ones are important and which ones are less important.*"

Overall, participants reported positive preference for receiving a text message with color-coded patient vital signs during the interview session. In addition, participants provided suggestions, which was used to derive design suggestions for improving the evaluated design of the patient-enhanced notifications (Table 1).

Discussion

There are multiple approaches to addressing interruptions. Some researchers have adopted the *impact reduction paradigm* to manage interruptions,[28] while others have adopted the *interruption value paradigm*[28] to aid in the decision-making of response to the TMNs. While using the former can have an impact on the quality of patient care owing to the complex temporal and mobile nature of ICU work,[2,3] the latter can add to the cognitive load already experienced by the receiving providers while evaluating the cost and utility of every TMN.[10] We chose to adapt the interruption value paradigm because of the freedom it allows for a receiving provider to determine how to respond to a TMN. By using a combination of fieldwork and focus group sessions, we proposed patient-enhanced notifications as a tool to circumvent the added cognitive load while managing interruptions from TMNs. This is a novel contribution that supports offloading the cognitive expense (such as memory, inferential strategies, and knowledge) faced by ICU providers when using technology-mediated communication. Further, our work contributes to the Institute of Medicine's (IOM) requirements of introducing health IT that does not increase cognitive load or alarm fatigue in the ICU.[38]

Table 1. Design suggestions

Description	Design Suggestion
Nurses suggested that the information that is often shared between one another is related to repeated interventions, such as, labs. P8 noted, "*Sometimes I prefer comparing a previous lab result just to see how the patient has been doing over time. Possibly it will be helpful if I could see just the previous and current lab result. I would anyways do this by going to the EMR if the results don't look good.*"	Display a previous intervention result in addition to current result to provide clearer understanding of the patient's progress over time.
Nurses found the term "Dismiss" unclear. They wanted an option that will allow a sender know that the receiver has seen his/her message. P5 noted, "*lets say the resident is busy and can't respond to my message immediately. If I can see that the resident has acknowledged my message, then I can move on and work on other activities since I have completed my part of work.*"	Replace the response option "Dismiss" to "Acknowledge"
All providers reported on the value of sending and receiving a response to a specific question from the colleague. However, "Dismiss" and "Respond" buttons were found not to support this functionality. P2 noted, "*it will make more sense to me if I see a question in the message and I respond with a yes or no, maybe for the no option, I can explain why I chose that response to the recipient.*"	Dynamically change the response options to "yes" and "no, respond" if the actual message is a question.
Nurses raised the issue of difference between communicating multiple topics within a phone conversation as opposed to conveying a single topic through a text message.	Change "Respond" option to allow providers to choose from a set of options: Callback and Text.
Residents and nurses raised the issue of trying to remember to respond to a patient notification if they chose "Acknowledge" at any point of time.	Add an option, where providers can set a time for the patient notification to pop up again; such as, "Remind me in 1 hr."

Our evaluation study demonstrated that ICU providers responded immediately to messages that provided more contextual information such as patient vital signs in addition to the actual message. The urgency as portrayed using color was intended to provide an indication for the providers to "glance at" and determine the importance of the notification. However, providers reported that explicitly depicting urgency might not be helpful initially, if only a single message is seen on the mobile device – suggesting that such a feature will be learnt over time. Providers reported finding it easy to direct their attention to abnormal values since they were colored red – similar to their mental model of attributing red color with abnormality. Further, providers reported being able to perceive the urgency of a message implicitly based on the patient vital signs and the actual message. Providers highlighted the inclusion of the patient vital signs with a text message as a significant contributor in aiding their decision on how to respond to the message – patient vital signs were considered as important information that can be "glanced at" during the decision-making of any patient activity. Based on our findings, we also provide some design suggestion for the patient-enhanced notifications (Table 1). Most of these suggestions revolved around the idea of providing more contexts to the receiver as well as simplifying the response process.

Study Limitations: This study chose a subset of additional patient information, cognitive, and environmental situations to present. For example, we chose not to vary the time of the day or relationship between the interrupter and patient. We did this to gain more experimental control. Also, the specific options we chose can be implemented in the ICU using existing technologies. For instance, the patient initials, room number, and vital signs can be automatically populated if the device is paired with the EMR; leaving the sender to only type in the actual message and choose the importance of the message with respect to his/her understanding of the patient's current condition. Another limitation is that this was laboratory-based. Consequently, how providers respond in a real-world setting can be affected by a variety of factors that we may be unaware of.

Conclusion

Managing interruptions is a major challenge in a busy, information-intensive ICU environment. In this paper, we adapt the interruption value paradigm[27] to suggest an asynchronous technology solution that can help receivers better manage interruptions. We were interested in understanding what features would best support a receiver's decision-making process in term of deciding whether or not to immediately respond to a TMN. Our proposed solution, also known as patient-enhanced notifications, used additional patient information (current vital signs and priority/urgency of the message perceived by interrupter based on patient's current condition) provided via text message previews. Our study showed that providers were receptive to the additional information and that it helped them in deciding whether or not to immediately respond to a TMN. We also highlighted some design suggestions, one of which points to combining asynchronous and synchronous communication capabilities of a technology tool. In summary, we believe that introducing an asynchronous mechanism that prompts a response phone call, by sending patient-enhanced notifications, has two positive outcomes. First, it can support a conversation of multiple topics and second, it can support the interrupted in better managing the interruptions generated by the TMN. As to future work, we intend to further examine the differences in better managing interruptions between an asynchronous solution (that facilitates conversation based on only one topic) as opposed to a synchronous solution (that facilitates conversation of multiple topics)

Acknowledgments

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