Nurse Perceptions of the Usability of Augmented Reality to Support Clinical Decision Making: Results of a Pilot Study

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Abstract

Clinically, nurses must rapidly identify deteriorating patients and escalate patient care to adverse events. Novices, however, can easily succumb to cognitive overload. Augmented-reality (AR) devices, such as the Microsoft HoloLens 2, may help nurses attend to task-relevant information more effectively. The aim of this pilot study was to assess experienced nurses' perceptions on the usability of AR. Practicing nurses were recruited for this study. Following a brief tutorial, demonstration and hands-on use of the HoloLens, nurses completed the system-usability scale (SUS) to rate usability. Additionally, interviews were conducted after the simulated use session. Experienced nurses (n=11) rated the usability of AR as 62.5±7.8. Themes that emerged from our open-ended interviews included the need for AR in nursing education and the potential benefit of a patient care checklist. Use of AR to support nurse decision making may reduce cognitive workload and focus attention on critical areas to recognize patient deterioration.

Keywords: Augmented Reality, Nurses, Students, Decision Making

Index Terms: Human computer interaction (HCI), Education

1 Introduction

In healthcare settings, failure to recognize patient deterioration can delay escalation of appropriate patient care protocols, which can increase the risk of adverse events for patients [1-5]. Given the time spent directly with patients, nurses are vital to quick recognition and response to patient deterioration. A recent review of the literature identified several sources of information that nurses utilize to assist with their timely recognition of patient deterioration (e.g., vital signs, regular patient assessments, review patient diagnostics, etc.) [6]. However, nurses must contend with several superfluous sources of information, which can divide their attention and increase cognitive load.

Working memory is a mental system responsible for temporary storage and manipulation of information [7]. However, this system has capacity limits. Cognitive load represents the demands on working memory, and if excessive, can overload an individual's working memory and lead to slowed decision making and decreased sensitivity to task-relevant stimuli [8-10].

Among nurses, ethnographic research has shown that in the clinical environment, nurses are frequently faced with interruptions to their care of patients, which can shift their focus to non-critical areas and increase cognitive load [11]. A review of the literature on factors contributing to nurses' cognitive load found that time pressure, multi-tasking, task complexity, and distractions also contribute to heightened cognitive load for nurses [12]. Our team has found that while experienced nurses develop cognitive schemas to manage the vast amount of information needed to care for patients [13], it is unlikely that novice nurses have developed these schemas which can put them at risk for cognitive overload [14]. Given their inexperience, novice nurses are at risk for cognitive overload. However, it is possible that augmented-reality (AR) devices may be able to augment and assist novice nurses when making clinical decisions.

Augmented-reality devices, such as the Microsoft HoloLens 2 (Microsoft Corporation, Redmond, WA), offer an ability to incorporate manipulable holographic images within the existing user environment. For nursing education, educators have used AR devices to develop novel methods for nursing simulation [15]. In one study, researchers utilized AR to allow nurses to scan equipment in the simulated environment and receive immediate video education on how to use that equipment, which participants perceived as beneficial to self-directed learning [16]. In another study, researchers utilized AR to visualize patient anatomy, which nursing students perceived as beneficial to their knowledge and understanding of human anatomy [17]. However, there is a lack of literature on the use of AR as a cognitive aid to support nursing students' clinical decision making. Accordingly, the purpose of this pilot study was to assess experienced nurses' perceptions of AR as a cognitive aid to assist with nurse decision making.

2 Methods

2.1 Study Design

The Purdue University Institutional Review Board reviewed this study and approved it after expedited review [IRB# 2020-1684]. Experienced nurses (i.e., in practice at the time of recruitment, ≥ 6 months post-training) were recruited to voluntarily participate in this study. Recruitment was from a convenience sample. Following participation in patient care simulations, nurses were presented the HoloLens 2 and were given a 10-15 minute guided, standardized tutorial by study team members to learn basic functionality (i.e., menu navigation, gesture and voice manipulation). Following this tutorial, nurses were presented some mock healthcare checklists for patient care tasks on the screen to demonstrate how AR can be implemented in a healthcare setting. Experienced nurses then completed a usability survey and provided feedback on how AR could be optimized to best aid nurse decision making.

2.2 AR Program Development

The Microsoft HoloLens 2 (Microsoft Corporation, Redmond, WA) is an AR headset designed to assist users with a variety of tasks (i.e., even highly technical and complex tasks) through the use of holograms overlaid in the physical environment. Using a time-of-flight depth sensor, interactive holographic overlays are displayed at an appropriate depth to the user. Furthermore, users

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are able to interact with holographic images using interactive touch, voice commands or hand gestures. The HoloLens 2 also allows researchers to track head movements using visible light cameras, and eye tracking using infrared cameras to track eye movements.

Using the Unity software development platform (Unity Technologies, San Francisco, CA), our team created a patient care checklist, which details several aspects of patient assessment (e.g., check vitals, review patient chart, etc.) (Figure 1).

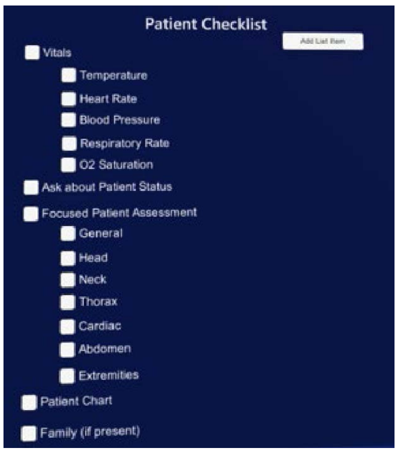

Figure 1: AR patient care checklist.

Users are able to scroll through the checklist using the interactive touch feature, and can "check off" items using interactive touch or voice control. This allows a nurse to document completion of tasks or assessments in real time.

2.3 Measures

The System Usability Scale (SUS) is a 10-item measure that assesses perceived usability of a device or program [18]. On a 5-point Likert scale, users rate their agreement with statements about a device (e.g., "I think that I would like to use this system frequently') ranging from strongly agree to strongly disagree. The SUS yields a single number reflecting overall usability of the system. Each question is scored from 0-4, as for odd-numbered questions scoring reflects the user response minus 1, and for even questions scoring reflects 5 minus the user response. The sum of these scores is multiplied by 2.5 and yields an overall score ranging from 0-100. Descriptive statistics (mean ± standard deviation) were calculated for experienced nurses and nursing student responses.

In addition to SUS scores, our team also solicited feedback on the applicability of AR for nurses by conducting semi-structured, open-ended interviews. Specifically, we asked them what benefit there would be (if any) to nurses using this device in simulation and clinically, what impact the device would have on cognitive workload, and what improvements could be made to the device to better help nurses.

Participating nurses' responses during these interviews were audio recorded and professionally transcribed. Utilizing a qualitative description approach [19], a member of the study team reviewed transcripts and identified relevant themes. A selection of representative quotes from identified themes have been extracted and included in the results section.

3 Results

3.1 SUS Scores

Eleven experienced nurses (18.1±11.3 years in practice) with diverse backgrounds (e.g., emergency, intensive care, psychiatry, medical surgery, obstetrics, adult critical care, telemedicine) completed the study. Experienced nurses rated the usability of the AR patient checklist as 62.5±7.8. A subscale analysis revealed that experienced nurses rated several positive aspects of the AR patient checklist highly, including: "I think that I would like to use the device frequently" (3.9±0.8), "I found the various functions in the device were well integrated" (4±0.7), and "I would imagine that most people would learn to use the device very quickly" (4.1±0.6). Conversely, experienced nurses also rated perceived some aspects of the AR patient checklist negatively, including: "I think that I would need the support of a technical person to be able to use the device" (3.4±1.1), and "I needed to learn a lot of things before I could get going with the device" (2.9±1.2).

3.2 Themes on Translation of AR in Healthcare Practice

Several experienced nurses provided feedback on the existing functionality of the AR patient checklist at the time of the study, and also provided feedback on the future potential of the AR to aid clinical decision making (Figure 2).

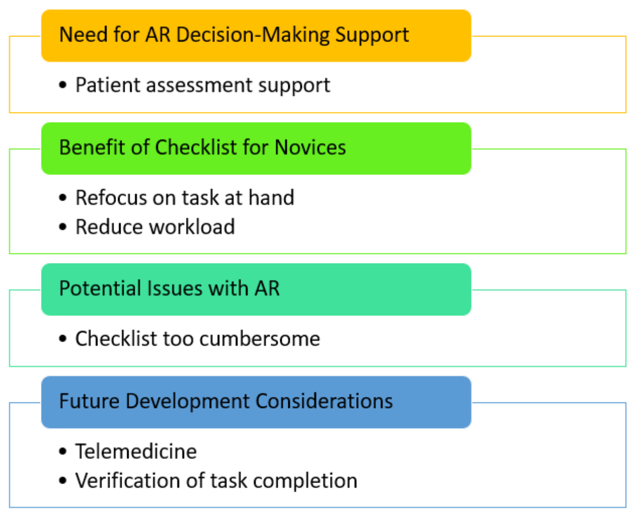

Figure 2: Themes on AR Decision-Making Support for Nurses.

Need for AR to Support Decision Making for Novice Nurses

One experienced nurse felt that AR is needed to support novice nurse decision making:

> I think that's a great invention that has huge potential. I think maybe students would know to call the doctor or call respiratory but they really need assessment skills and to pick up on the abnormal. They may not know what, but at least they can pick it out that something is there. That is a huge problem in hospitals right now, is they just don't have that decision-making capability and judgment skills.

This quote exemplifies the need to support novice nurses in their assessment of patients.

Benefit of Patient Checklist to Novice Nurses

One experienced nurse felt that the patient checklist would enable novice nurses to remained focused on the task at hand: "Having a mental checklist will help new nurses refocus back on the tasks at hand." This nurse also felt that AR could help reduce novice nurse cognitive workload: "Once the training is there, and you have a comfort level with it, absolutely. It would be beneficial [to reduce workload]."

Potential Issues with AR

In regards to potential issues nurses may face when utilizing AR, one nurse felt that the patient checklist could be too cumbersome:

> If you're going to use it with real patients, I think it could be cumbersome… there might be too much interplay to get your tasks done that you need to accomplish in a real-life situation. But I could see it used more for training, but not necessarily at the bedside directly. I think to use it in a real-life situation, they'd have to be really proficient with it.

Based on this quote, systematic training would be needed to adequately prepare nurses to utilize AR clinically.

Future Development Considerations

Regarding future potential development considerations for AR, experienced nurses felt that the hologram could be leveraged to engage in telemedicine: "We're dealing with telemedicine right now, and if someone is like 'Hey look at my guy for a second' it would allow you to go see the patient without having to physically be there." Another nurse felt that the eye-tracking capabilities of AR devices could be used as a verification that novice nurses were performing needed tasks for patient care:

> The idea is that if you have a brand-new nurse, and it's like their first or second week, you're kind of with them all the time, but the longer that they're there you kind of pull back and let them do more independently. Well, something like that where it'll allow the preceptor to say, 'If you charted it, yeah, you charted it, but I don't know that you actually did it.' And that [eye-tracking] would tell you that they did it.

4 Discussion

Our team sought to perform a pilot study about the usability of AR to be a cognitive aid to novice nurses, and the results from this study are encouraging. Experienced nurses rated the usability of the AR patient care checklist as moderate, but a subscale analysis identified several positive aspects of usability. Specifically, nurses reported that learning to use the AR checklist would be quick, the device functions were well integrated, and importantly, they would like to use the patient checklist frequently. From these ratings, we can surmise that even experienced nurses perceived a benefit in utilizing an AR cognitive aid to benefit their clinical decision making.

Research from our group on nurse decision making has found that experienced nurses systematically work through a multitude of factors related to patient assessment, and utilize critical thinking to rapidly accept or deny information based on its pertinence [13]. We hypothesize that our developed AR program will enable nurses, particularly novices, to do this efficiently and effectively. One nurse in our current study emphasized that novice nurses need assistance with the patient assessment process. The AR checklist can help novices sequentially move through the assessment process and avoid missing any critical sources of information. We also hypothesize that our AR program will help reduce nurses' cognitive load in the clinical environment, which may better preserve decision making.

Research on cognitive load has shown that cognitive overload can contribute to several cognitive deficits, particularly slowed decision making [8-10]. Given the need for nurses to rapidly process information and make timely decisions to recognize patient deterioration [6], these cognitive deficits are very salient. Research has shown that nurses are faced with a multitude of factors in the clinical environment that can increase workload, including constant distractions and interruptions to workflow [11,12]. Due to their inexperience, novices may not have formulated the cognitive schema necessary to refocus back to task-relevant stimuli. Our developed AR patient checklist can address this issue. As one nurse pointed out in our study, having a mental checklist readily available will help novices refocus back to the task at hand more effectively. This can ameliorate the issues to cognitive load presented by regular distractions and interruptions.

There were some conflicting results regarding the training needed to operate the AR program. Nurses felt that the checklist would require the assistance of a technical expert to help them learn to operate the device and there were several things needing to be learned before being able to operate the system. These sentiments were emphasized with a quote from one experienced nurse who felt that using the AR patient checklist clinically would necessitate a high-level of proficiency to avoid being cumbersome. However, nurse responses on the SUS also indicated that learning to operate the system would be a relatively quick process. These findings indicate that while learning to operate the AR system and checklist may require assistance from a technical expert and time to learn its functionality, the learning curve needed to master the checklist would be relatively quick. It is possible that dedicated training in patient care simulations may quickly help nurses master the checklist in a risk-free environment prior to clinical implementation.

There are limitations with this study. Our team utilized self-report measures of usability, which can introduce bias. That being said, the SUS is one of the most well-researched usability assessments used in engineering and has strong psychometric properties. We were also limited by logistic constraints in the amount of time we could devote to HoloLens training with experienced nurses. Furthermore, we did not implement the HoloLens with experienced nurses during an actual simulation, so perceived usability may have been limited by these factors. However, experienced nurses still rated the usability of the AR patient checklist as moderate, which is encouraging. Lastly, we conducted initial usability testing of the AR patient checklist with experienced nurses, which may limit the generalizability of our findings to less experienced nurses. Given their contextual knowledge of clinical nursing, however, experienced nurses can conceptualize how AR may be leveraged to be of optimal benefit to nurses.

4.1 Future Directions

Moving forward, our team is interested in identifying additional applications of AR in nursing. We also aim to study perceived usability of AR among nursing students to compare differences in usability between novices and experienced nurses. Additionally, given the potential use of AR to create dynamic holographic displays, our team plans to update the AR interface design to help improve its usability. Lastly, we plan to collect more objective data related to nursing student usability of AR during simulated clinical encounters.

5 Conclusions

In conclusion, our team aimed to assess experience nurses' perceptions about the usability of a mixed reality program to support nurses' clinical decision making. We found that experienced nurses found a patient care checklist presented through AR to have moderate usability, but reported wanting to use the technology frequently. Nurse feedback indicates this technology could be helpful to reduce cognitive load and help students remain focused on the tasks at hand for patient assessment and care. While there were some questions regarding applicability of this device in the clinical environment without sufficient training, our team is encouraged by these findings and will continue to optimize this technology to support novice nurse decision making.

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