8-2014

Design of a Sign-Out Process to Improve Surgical Safety

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DESIGN OF A SIGN-OUT PROCESS TO IMPROVE SURGICAL SAFETY

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Industrial Engineering

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by
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August 2014

Accepted by:
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ABSTRACT

According to the World Health Organization (WHO), the surgical safety checklist consists of three parts; sign-in, time-out and sign-out. It has been observed that the sign-out process is the least frequently completed. In this study, because of a concern for the risk of adverse events occurring in the OR, the sign-out process used in a local hospital was redesigned as a web-based application embedded on a desktop computer and on a mobile device. Both web-based platforms were tested along with the current sign-out process on a computer. Eighteen circulating nurses in the operating rooms of Greenville Memorial Hospital used each of the three sign-out platforms at the end of various surgeries—the current sign-out process on a desktop, the sign-out process using the WebApp on a desktop and the sign-out process using the WebApp on a tablet. Time, performance, workload measures, system usability measures and satisfaction measures were recorded and analyzed.

The time to complete the sign-out process was the longest using the WebApp on the desktop and the shortest using the current sign-out process. The web-based app on both the desktop and the tablet resulted in fewer sign-out process items being skipped than the current system. The web-based app on the desktop resulted in fewer items not being discussed than the current system. Frustration with the sign-out process was rated as higher with the current system than with the WebApp on the desktop. The web-based app on the desktop was rated significantly higher than the current system for situation awareness, ability to detect errors, ability to understand the benefits of performing the

sign-out process, and ability of information to be viewed all at once. The WebApp on both the desktop and the tablet was rated significantly higher than the current system for maintaining records and for accessibility from all locations. Fourteen participants preferred the sign-out process using the WebApp on the desktop while two preferred the current system and two preferred the WebApp on the tablet.

DEDICATION

This thesis is dedicated to my loving and supporting parents, my mother Kasamsant Chompoodang, my father Surapon Noppakunwattanakul, my husband George Michael Gmitro Jr., my mother-in-law Tracee Green Gmitro, my father-in-law George Michael Gmitro and my siblings Prangthip Chompoodang, Katherine Maria Gmitro, Anna Grace Gmitro, David Sterling Gmitro and my loving friends.

ACKNOWLEDGEMENT

This research was made possible by many people of Clemson University and Greenville Memorial Hospital but two people, in particular, were with this research from beginning to end. Dr. Joel Greenstein, Associate Professor at Clemson University and research advisor, assisted me in the entirety of this research. He had many ideas that were implemented in this research and suggested many more. He helped me when I confronted problems and helped me solve them. Richard Wilson, CRNA and Assistant Program Director of the Graduate Program in Nurse Anesthesia at Greenville Memorial Hospital, made me feel welcome at his hospital and accepted my ideas with ease. He provided access to the hospital, advised with medical knowledge, and gave me several applicable ideas for this research. He knew this research so well that he spoke at a conference on my behalf, describing the details of this research to his colleagues. He spent many hours helping me recruit participants, ensuring this research would be completed as soon as possible. I am sincerely thankful for their dedication to my research study.

I would like to thank my committee members, Dr. Anand K. Grampoadhye and Dr. A. Joy Rivera, for supporting this research study from the beginning to the end, especially in suggesting additional ideas that were implemented in this research. Also, Ms. Barbara Ramirez was invaluable in assisting me in the writing of this entire research paper.

I thank my colleagues, Venkatramanan Chanchapalli Madhavan and Mahesh Sreedharan for helping with data collection. A special thanks to Reshmi Koikkara for

suggesting the experimental design and statistical analysis tools in this research. Kevin Juang helped me rehearse for my defense and was there to give suggestions during the course of my research.

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CHAPTER I

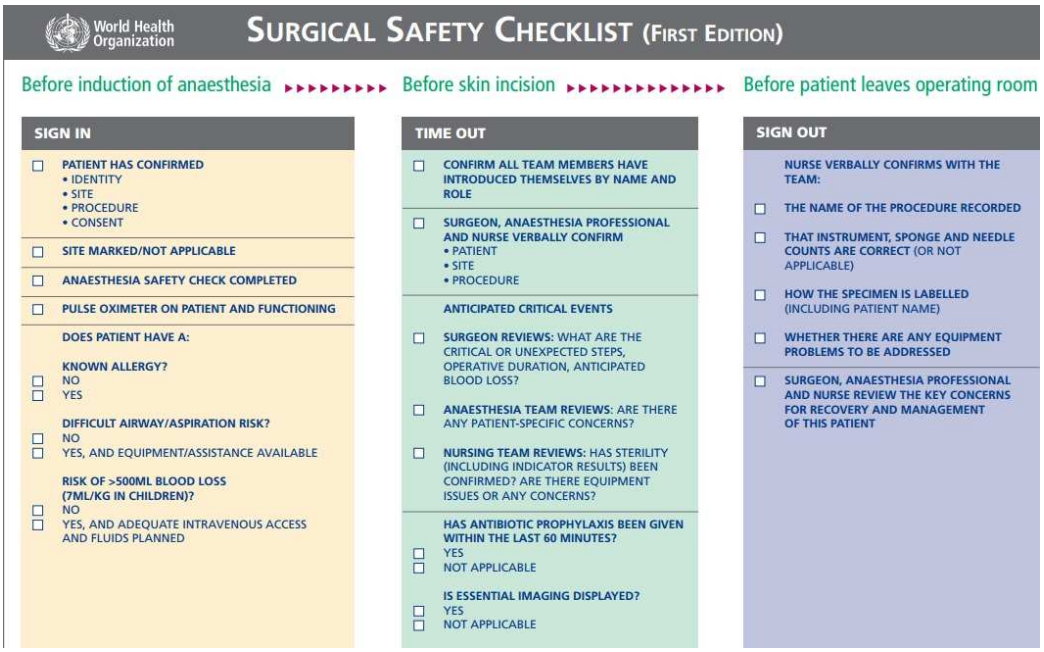
INTRODUCTION

Surgery is an integral part of health care, with an estimated 234 million operations performed yearly (Weiser, Regenbogen, Thompson, Haynes, Lipsitz, Berry & Gawande, 2008). Although surgery care can prevent loss of life and limb, it is also associated with a risk of complication and death, with research suggesting that at least half of these can be avoided (Weiser et al., 2008). Previous efforts to implement practices designed to reduce surgical infections or anesthesia-related issues have been shown to significantly reduce complications (Classen et al., 1992 and Runciman, 2005). Specifically, a growing body of research suggests that teamwork improves surgical outcomes, with Sexton, Makary, and Tersigni (2006) finding that communication among surgeons, anesthesiologists, and nurses is critical in preventing surgical complications.

One way to improve communication is through the use of a surgical safety checklist, the earliest being developed in 2008 by Dr. Atul Gawande, Director of the WHO's Global Challenge for Safer Surgical Care. Its goal is to reduce surgical error and standardize the surgical safety process. It is flexible, universal and can be adapted according to where and when it is implemented (World Alliance for Patient Safety, 2008). This surgical safety checklist is applied in 3 phases, referred to as the sign-in, time-out, and sign-out. During the sign-in, the patient's identity and consent for surgery are confirmed, the operative site is marked and the risk of blood loss, airway difficulty, and allergic reaction are reviewed. During the time-out phase, team members introduce

themselves, confirming out loud that they are performing the correct operation on the correct patient and site, and verbally reviewing any critical elements of the operation. Antibiotic administration and imaging availability are also confirmed, as appropriate. The sign-out phase guides the review of the operation performed, including the completion of sponge and instrument counts, the labeling of any surgical specimens, the identifying of equipment malfunctions or issues, and the review of the key plans and concerns for postoperative management and recovery. In each phase, the checklist helps confirm that the surgical team has completed its critical safety tasks.

Elements of the surgical safety checklist in the WHO version are shown below in Figure 1.1:



Figuree 1.1. WHO Surgical Safety Checklist: First Edition

As this figure indicates, it consists of basic tasks arranged in a logical sequence and involves the patient and all members of the surgical team. While its components are intended to ensure the commission of specific safety steps, as well as to enhance team functionality and communication in the OR (WHO, 2008), the problem is that no single person is responsible for the entire verification procedure.

Past research has found other issues with the checklist, one being the fact that it was recalled from memory. Lingard et al. (2004) found that the number of unchecked items on a surgical safety checklist varied widely across surgical cases because, as the surgical staff repeatedly and routinely use the surgical safety checklist, it became easy to forget some of these items. Undre (2006) found, of 50 surgical cases, significant steps were missed because the staff verbally recalled the items from memory rather than reading the list. In addition, incorrect data entries and misunderstandings among surgical staff during the procedure were found (Undre, 2006).

To address these issues, Thomassen, Brattebo, Softeland, Lossius, and Heltne (2010) suggested the development of a checklist process that required surgical staff to interact with each item and to report the completion of the checklist to management-level personnel. Parad et al., (2010) implemented a process in which the surgeons and anesthetists involved in a particular surgical case listed unexpected events, set up an alert system for staff in the OR, and made the presence of the anesthetist compulsory at the end of each surgical procedure in order to share information on drug prescriptions. By

ensuring the completion of every checklist, and asking for regular feedback, these procedures led to improved communication among surgical staff with management.

More specifically, these issues and concerns were supported by interviews and observations conducted at Greenville Memorial Hospital (GMH). These interviews and observations suggested that the format of the standard surgical safety checklist currently used might not be equally suitable for the variety of procedures that take place in this hospital. They also suggested that the sign-out process was not completely and appropriately performed by surgical staff. Frequently, the surgeon left the operating room before the sign-out process was initiated. Therefore, at the end of the surgery, there was no discussion confirming the procedure that was performed, the correctness of the instrument counts, and the concerns that the staff may have. These observations also suggested that users of the current checklist may unintentionally skip items in the checklist because they relied on their memory of the checklist's content instead of consulting it directly.

To address these concerns, this study sought to analyze various methods of delivering the sign-out portion of the Greenville Memorial Hospital surgical safety checklist by applying human factors principles and user-centered design methodologies. These principles and methodologies were used to design, implement, and test methods of presenting information to the surgical staff for executing the sign-out process. Electronic devices are becoming an important tool widely used by health care professionals (Gillingham, Holt and Gillies, 2002). They have been found to be an effective approach

for reducing omission errors while increasing surgical team response rates and improving checklist accessibility (Krüger, Wuchol, and Beckstein, 2012). They potentially add value to clinical practice in a number of ways, including giving clinicians access to clinical information where and when it is needed, improving the exchange of information, and providing clinical decision support at the point of care (Ruland, 2002; Bates and Gawande, 2003; Kaushal and Bates, 2002). Thus, the use of electronic devices was explored in this research study. It was expected that a redesigned presentation of the sign-out process would reduce the number of items skipped, improve the overall quality of the process, and encourage surgical staff to use it routinely. The performance of the redesigned sign-out process was compared with the current sign-out process in the ORs at Greenville Memorial Hospital.

CHAPTER II

LITERATURE REVIEW

Surgical Safety Checklists

Over the past 70 years, the aviation industry has contributed much research in the development of checklists (Hales & Pronovost, 2006). Recognizing the likelihood of human error under daily work conditions, these checklists focused on compensating for such errors in the aircraft industry (Helmreich, Wilhelm, Klinect, & Merritt, 1991). There are several types of checklists integral to regular flight practices, including preflight, cockpit, starting engine, landing, and shutdown checklists (United States Air Force Series, 1999); as Helmreich (2000) found, the use of such aircraft checklists improves airline industry safety. Given these results, Toff (2010) applied some of the lessons learned from aviation checklists to healthcare. One such tool adapted from the aircraft industry is the surgical safety checklist.

The most widely used surgical safety checklist was developed by Dr. Atul Gawande, Director of the WHO's Global Challenges for Safer Surgical Care in 2008. It is a 19-item checklist intended to reduce the rate of major surgical complications that occur in the operating room (OR), including operating on the wrong site, performing the wrong procedure, operating on the wrong patient, and using the wrong surgical equipment (World Alliance for Patient Safety, 2008). A second goal of this surgical safety checklist was to standardize surgical safety. While it is discouraged to remove items from it because they cannot be accomplished in the existing environment or circumstances, it can

be modified to account for processes used in different facilities, the differences in the culture of operating rooms, and the level of familiarity of the surgical team members with one another.

The WHO checklist is a two-minute tool, much like the one a pilot uses before takeoff, designed to help operating room staff collaborate to ensure the consistent use of safety processes. Divided into three phases, sign-in, time-out, and sign-out, it allows each member of the surgical team to review information given by the others to ensure critical tasks are done by embedding the idea of open communication from the beginning to the end of the operation. Research conducted by Vats (2010) found that sign-in and time-out are completed consistently but sign-out is rarely done because it is unclear when this process should be initiated. Some nurses were observed to be reluctant to remind the surgeon and anesthesiologists to complete sign-out items. Furthermore, dismissive answers were often given without a request for confirmation or clarification by other professionals on the surgical team. Vats found that the primary reason for these issues was that the end of the procedure is a busy time in the OR, with the Certified Registered Nurse Anesthetist (CRNA), circulating nurse, anesthesiologist, and surgeon each focusing on their individual tasks. It is a particularly critical time for the anesthesiology team because they are waking up the patient.

A second reason for the lack of use of the sign-out process is that while the time-out is a natural pause in the surgical process when the team comes together before the incision, there is no equivalent pause at sign-out. At this time, the surgeon and the

nursing team are responsible for confirming that equipment counts are correct and that the specimens have been correctly labeled. However, rarely does the sign-out process coordinator verbally confirm whether there are any key concerns for patient handover or if there are equipment issues that need to be addressed. These issues are further complicated by the fact that in some ORs the checklist is performed verbally from memory (Conley, Singer, Edmondson, Berry, & Gawande, 2011). Thus, at the end of each section of the checklist, the surgical staff cannot be certain that every item has been completed because they cannot compare their actions against a reference checklist.

Even with these concerns, the use of the surgical safety checklist has led to a decrease in surgical mortality and morbidity rates. According to Haynes et al. (2009), its use has led to a significant reduction in postoperative mortality from 1.5% to 0.8% ($p=0.003$) and in morbidity from 11% to 7% ($p< 0.001$). This reduction rate is important because according to de Vries (2008), 40% of adverse surgical events occur in the OR, events that are often the results of avoidable errors.

Even with this improvement in safety, there are still problems with the checklist. According to the 2012 study conducted by Fourcade consisting of 1,299 paper-based checklists and 28,578 individual checklist items, only 61% of those received were completed. This study also reported that most of the missing items (47.42%) were associated with the sign-out process. More importantly, his study identified 11 barriers to effective implementation of surgical safety checklists. The most important issue is that paper-based checklists alone cannot encourage communication among the surgical staff

during the sign-out process. Secondly, there was no record of the checklist being completed. In addition, surgeons often leave the OR before the sign-out process is performed, and anesthesiologists may not return to the OR until after skin closure, suggesting neither is aware of the sign-out process.

Paper-based Versus Electronic or Computer-based Checklists

The advent of the digital age has led to research comparing paper-based and electronic-based checklists. A study conducted by Verdaasdonk, Stassen, Widhiasmara, and Dankelman (2009) considered the advantages and disadvantages of paper-based checklists for surgical procedures. The advantages of the paper-based checklist are its low cost, low technical complexity, and high reliability because it is independent of power supply, maintenance, or computer malfunction. Paper-based checklists are portable so staff are able to carry them anywhere they go. A disadvantage of reusable paper-based checklists without marking is that there is no record of completed items, and it does not prevent items from being skipped. Paper-based checklists may also be difficult to update if items are revised or new items need to be added.

These disadvantages can be addressed by the use of electronic devices. Rouse, Rouse, and Hammer (1982) compared the performance of paper-based and computer-based aircraft checklists, the results showing that pilots made significantly fewer errors using an electronic checklist than with a paper one. However, completion time was longer for the electronic list. Blike and Biddle (2000) also found that an electronic checklist was superior to the standard Food and Drug Administration (FDA) approved

paper checklist in detecting equipment faults. With the wide variety of electronic devices available today, they appear to reduce the rate of medication errors (Stead & Lin, 2009). In addition, electronic checklists can be updated automatically after revisions, and an electronic checklist can be sent, received, and store information on compatible systems or devices. Another potential advantage of an electronic checklist is the possibility of designing a system that prevents the beginning of a procedure unless the checklist is completed.

While one option is a mobile application, a web-based one has been found to be more efficient because it does not depend on a specific device (Wantland, Portillo, Holzemer, Slaughter, & McGhee, 2004). A study conducted by Deo, Deobagkar, and Deobagkar (2005), using web-based database management to help improve data collection, management, and analysis of information for diabetes patients, found that an interactive web interface allowed easy access to information and generated reports for medical staff and patients. In addition, Holzinger and Errath (2007) conducted a study using a user-centered design methodology to adapt web applications to increase the accessibility of healthcare information. They found that while they are accessible throughout different platforms, factors, such as size of the screen and resolution of the device that differentiate mobile platforms from each other, affect usability for end-users.

Past research has found that a surgical safety checklist is able to improve the quality of patient safety. However, there are still problems: while two sections of the checklist, sign-in and time-out, are often completed, it appears that sign-out is often not.

Moreover, surgical staff often complete the checklist from memory without referencing a physical checklist to assure that every item in the checklist is completed, allowing for commission and omission errors. Without communication and discussion at the end of surgery, the opportunity to detect errors and inconsistent information between staff is lost. To address the use and problems of the surgical sign-out process, a user-centered design methodology was used in this study to develop an efficient and effective sign-out process that was compatible with the surgical team's workflow and was more usable than the current sign-out processes. As research has shown that electronic devices have the potential to address these problems, this research proposed to redesign the sign-out process using a web application delivered on electronic devices such as desktop computers and tablets.

CHAPTER III

DESIGN OF THE SIGN-OUT PROCESS

The goal of this research was to redesign the sign-out portion of the surgical safety checklist procedure using a User-Centered Design (UCD) methodology in consultation with healthcare professionals at Greenville Memorial Hospital. This research was conducted in two phases: the first phase involved the design of a sign-out system scheme following a user-centered approach, and the second phase involved an experimental study to test the performance of this scheme during actual surgical procedures. This methodology, adapted from Ulrich and Eppinger (Ulrich & Eppinger, 2011), was customized to suit the needs of this research and includes the following steps:

1. Identification of user needs
2. Identification of metrics
3. Concept generation, detailed design and refinement
4. Concept testing

Phase I of this research, the design of the sign-out process, included Steps 1, 2, and 3, while Phase II, which is Step 4, focused on the testing of the design with representative users during actual surgical procedures.

Step 1. Identification of user needs

Interviews and observations

Step One began with interviews and observations of medical professionals in the Greenville Memorial Hospital upon IRB approval by Clemson University and Greenville Memorial Hospital (Appendix A). Potential participants were recruited at Greenville Memorial Hospital (GMH) through direct contact and e-mail by research team members. This study was based on interviews with 3 surgeons, 2 anesthesiologists, 3 CRNAs, 3 RNs, 3 surgical technicians, and 2 administrators. Its purpose was to better understand the needs, concerns, and goals of the sign-out procedure stakeholders. Each participant was provided with the interview questions one day in advance. Participant responses were initially recorded as handwritten notes by the research team and then transcribed into a word processor document. Each interview, which took approximately 30 minutes, consisted of one or more interviewers discussing checklist needs with a single interviewee or with a small group of interviewees.

Thirty-eight observations of surgical teams using the current WHO surgical safety checklist adapted for the GMH during surgery took place over 11 days. These observations were conducted to better understand the surgical checklist process and to gain information based on direct interaction and experience with the surgical safety checklist procedures in the OR environment. The observations included a variety of surgical cases and teams including a surgeon, an anesthesiologist, a CRNA, an RN, and a

surgical technician. Similar to the interviews, the researcher took handwritten notes, which were then transcribed into an electronic document.

Content analysis was used to evaluate the information gathered during the interviews and observations. Several studies have indicated this approach was effective in exploring current situations and how individuals felt about them, and for identifying potential solutions (Kaufman et al., 1993), (Rossett, 1987), (Kinzie et al., 2002).

Results—Interviews and Observations

The research team summarized the qualitative findings from each interview session in a customer data template, which included the interview questions, the customer statements and the interpreted needs statements as shown in Table 3.1. Overall, 39 needs statements were identified and organized into a hierarchy of 11 primary needs and 39 secondary needs (Table 3.2). The primary needs were created by categorizing similar need statements. Twenty-five needs were also identified as latent by the participants. Each latent need was identified according to more than 8 out of 16 participants indicated that the need was unique or unexpected. These unique or unexpected needs are shown in Table 3.2.

Surveys

The secondary needs were interpreted, grouped, and translated into a survey of the 39 statements (Appendix C). Sixteen surgical staff members were recruited through direct contact and e-mail by research team members to complete this survey. After agreeing to

participate, participants first signed the consent form (Appendix B). Then, each was provided with the survey of the 39 need statements resulting from the interviews. Participants were asked to rate the relative importance of each on a 1 – 5 scale, with 1 being the least important and 5 being the most important needs to be addressed in the proposed solution. The survey results were used to improve the understanding of how checklists are used in practice and to suggest future research that could improve their effectiveness.

Results—Surveys

Critical needs were identified as those with an average rating of 4.5 or higher for all users. The resulting 19 critical needs pertained to the following 7 of the 11 primary needs: the sign-out process is used, the sign-out process is easy-to-use, the sign-out process is quick to complete, the sign-out process organizes information, the sign-out process provides situational awareness, the sign-out process supports communication among surgical staff, and the sign-out process ensures task completion.

The completion of Step 1 provided a detailed look at the needs, concerns, and problems of the current surgical sign-out process to consider when redesigning it. The research team used this information in Step 2 of Phase I, the identification of metrics.

Table 3.1

User responses and interpreted needs

Question/Prompt	*Response*	*Interpreted Need*
1. Can you explain your role in the day-to-day work related to the use surgical safety checklists at GHS?	I am making sure at the beginning of the surgery that the checklist is completed and everything is documented. I sometimes need to remind the surgeons to do timeout. Basically we don't do the sign-out. We kind of informally cover the sign-out. You should be able to pull it up from the computer onto the monitor, that's the way to know that the checklist is completed. My role as a manager is to respond to questions and concerns about correct process and protocol, to explain process of protocol and the standard policy of the checklists to my staff. I am also responsible for clearing misunderstandings pertaining to the guidelines of the checklists.	• The sign-out process ensures that users complete the sign out process. • The sign-out process helps participants to remember to complete the sign out process. • The sign-out process is accessible from every location in the OR. • The sign-out process promotes understanding of the importance of completing the checklist. • The sign-out process ensures that participants understand what information is required to complete the sign-out process. • The sign-out process ensures that users understand the benefits of the sign-out process. • The sign-out process helps users to be aware of their roles in the sign-out process. • The sign-out process ensures that all surgical staff members are aware of their responsibilities for the patient in the OR.
2. What are your typical uses of surgical safety checklists?	We do it for every procedure, we do it for every surgery, I introduce myself to the patient, evaluate the airway, we have to do the last safety check.	• The sign-out process ensures that participants complete the sign-out process with every patient. • The sign-out process enables errors to

	There have been incidents in the past when there was no site marked and the surgeon operated on the wrong side. I do it for every case and every location. We have checklists everywhere we go in the hospital.	be detected easily. • The sign-out process helps to reduce the number of errors made in the OR. • The system is available from every location. • The sign-out process makes surgical staff aware of the sign-out process.
3. Could you please explain how you normally use surgical safety checklists?	I pull it from the screen by using the touch screen. It doesn't take a lot of time. I call the anesthesiologist and surgeon to do the timeout. I open the consent and the surgeon reads it. We discuss the checklist, whether the site is marked. Sometimes it is hard to read because the monitors aren't big enough. We have to go through the entire list. We have PowerPoint from the intranet. Staff can use the checklist anywhere and anytime and can use it with any kind of device that has access to the GHS server. All of these computers have access to the checklist because they have access to the intranet. The checklist is sometimes too generic. Some questions don't apply to a specific case.	• The sign-out process ensures that the sign-out process is discussed by all users. • The sign-out process is accessible at any time. • The sign-out process is accessible from every location in the OR. • The sign-out process presents information that is easy to read. • The sign-out process is quick to complete. • The sign-out process is concise.
4. How would you personally define success for surgical safety checklist implementation?	The checklist is not completed by many surgeons. The checklist helps to clarify things that we might overlook or not think about. The checklist helps us to correct our charting. We sometimes have surgeons from other hospitals/departments. They	• The sign-out process encourages participants to complete the sign-out process. • The sign-out process is quick to complete. • The sign-out process encourages

	may not know about the checklist. There is a checklist on the monitor as well as on the wall. I normally do it from memory. There's no way that I know if I have completed everything in the checklist. Unless I look at the paper or the monitor to make sure that I have gone through everything.	inexperienced users to complete the sign-out process. • The sign-out process integrates well with the existing workflow. • The sign-out process makes it clear when the sign-out procedure is completed.
5. What problems or inefficiencies have you experienced while using the checklists?	Getting everybody to listen to each other, especially when someone wants to start the timeout procedure. They were in other conversations, such as phone calls. At the CRNA/Anesthesiologist monitor, there is a button that we can confirm the time out being done, but not for the sign-out procedure. I think sometimes it takes too long to perform the checklists/go through every item.	• The sign-out process supports effective communication among the surgical staff. • The sign-out process ensures that the sign-out process is completed at the end of every surgery. • The sing-out process is quick to complete.
6. What are the barriers that might prevent you from using surgical safety checklists?	Surgeons don't complete the checklist. They can do it but they normally don't. I think it just bothers them when they just want to get started on the next procedure immediately. Emergency cases in which you do not have the lists available. Each nurse may have something else that they have to focus on, so they don't pay attention to the checklists that much.	• The sign-out process encourages participants to complete the sign-out process. • The sign-out process is quick to complete. • The sign-out process integrates well with the existing workflow. • The sign-out process is immediately available when surgical staff enter the OR. • The sign-out process supports emergency cases. • The sign-out process can be picked up easily where it was stopped due to an

		interruption.
7. Could you tell us more about approaches and features that would encourage the use of surgical safety checklists?	Make it simple, not wordy. Place the time out and the sign-out in a place where people can see them. It is frustrating when someone comes along and pulls up something else and then I have to pull the checklist back up again. We use it so that everybody is on the same page. The checklist should be very easy to pull up on the monitor and easy to navigate, especially for the nurse to use. Put together a presentation and make it available in the room. You have a PowerPoint presentation that has the individual questions of the checklist that we can scroll through once the patient enters the OR. A PowerPoint presentation and verbal communication are keys. I have no way to know if checklist items are skipped.	• The sign-out process is simple. • The sign-out process is easy to use. • The sign-out process maintains a record of the sign-out process. • The sign-out process can be picked up easily where it was stopped due to an interruption. • The sign-out process promotes effective communication. • The sign-out process supports effective communication among the surgical staff. • The sign-out process encourages vigilance with respect to the sign-out process. • The sign-out process is easy to access. • The sign-out process is standardized across all surgical procedures. • The sign-out process makes it clear when a step in the sign-out process has been skipped.
8. Other questions and wrap-up.	It would be easier to use it when sign-outs are on one screen. It needs to be better organized. The checklist should tell you what you need to know (according to the checklist), but the current organization of the checklist does not make clear what I should know in advance to be able to tell/talk to my team.	• The sign-out process enables all of the relevant information to be viewed at once. • The sign-out process ensures that participants understand what information is required to complete the sign-out process. • The sign-out process organizes information logically.

	I don't want anything complicated. The sign-out is the problem. I don't always remind the surgeon to do it. We get busy at the end of the case. The surgeons leave before the case is completely finished. There are a lot of monitors and they are visible. A poster on a wall should not be in the OR. We used to have a poster on the wall but we don't use that anymore. The checklist is available on the computer. We just don't use it.	• The sign-out process is simple. • The sign-out process ensures that the sign-outs are completed before participants leave the OR. • The sign-out process encourages users to complete the sign-out process before leaving the OR. • The sign-out process is visible. • The sign-out process encourages consistent use.

Table 3.2
Hierarchical list of needs

Avg. User Rating	*Latent Need*		
		1.)	**The sign-out process organizes information.**
3.5	!		1.) The sign-out process helps users to be aware of their roles in the sign out process.
4.6	!		2.) The sign-out process organizes information logically.
4.7	!		3.) The sign-out process is standardized across all surgical procedures.
4.8			4.) The sign-out process is concise.
		2.)	**The sign-out process is accessible**
4.1	!		5.) The sign-out process is accessible from every location in the OR.
3.6	!		6.) The sign-out process is accessible at any time.
3.4	!		7.) The sign-out process is readily available when surgical staff enter the OR.
		3.)	**The sign-out process ensures task completion.**
4.8			8.) The sign-out process ensures that the sign-out process is completed at the end of every surgery.
4.9	!		9.) The sign-out process ensures that sign-outs are completed before surgical staff leave the OR.
4.6	!		10.) The sign-out process ensures that surgical staff complete the sign-out process.
		4.)	**The sign-out process is compatible with the staff's work environment.**
3.9	!		11.) The sign-out process supports emergency cases.
4.4			12.) The sign-out process integrates well with the existing workflow.
4.2	!		13.) The sign-out process can be picked up easily where it was stopped due to an interruption.
		5.)	**The sign-out process supports communication among surgical staff.**
4.6	!		14.) The sign-out process supports effective communication among surgical staff.
4.6	!		15.) The sign-out process promotes effective communication.
4.0	!		16.) The sign-out process ensures that sign-out process is discussed by all users.
		6.)	**The sign-out process is easy to use.**
4.9	!		17.) The sign-out process is simple.
4.5	!		18.) The sign-out process presents information that is easy to read.
4.8			19.) The sign-out process is easy to use.
		7.)	**The sign-out process provides situational awareness.**

4.6	!		20.) The sign-out process helps participants to remember to complete the sign-out process.
4.4			21.) The sign-out process ensures that all surgical staff members are aware of their responsibilities for the patient in the OR.
4.0			22.) The sign-out process promotes understanding of the importance of checklists.
4.4	!		23.) The sign-out process enables errors to be detected easily.
4.6	!		24.) The sign-out process notifies users when the sign-out procedure is completed.
4.4			25.) The sign-out process makes surgical staff aware of the sign-out process.
4.7	!		26.) The sign-out process ensures that participants understand what information is required to complete the sign-out process.
4.2			27.) The sign-out process ensures that users understand the benefits of the sign-out process.
4.9			28.) The sign-out process helps to reduce errors made in the OR.
4.3	!		29.) The sign-out process notifies users when a step in the sign-out process has been skipped.
		8.)	**The sign-out process is used.**
4.5	!		30.) The sign-out process encourages consistent use.
4.4			31.) The sign-out process encourages users to complete the sign-out process.
4.1			32.) The sign-out process encourages inexperienced users to complete the sign-out process.
4.5	!		33.) The sign-out process encourages users to complete sign-outs before leaving the OR.
4.7			34.) The sign-out process ensures that users complete the sign-out process with every patient.
4.4	!		35.) The sign-out process encourages alertness with respect to the sign-out process.
		9.)	**The sign-out process is visible to users.**
4.1			36.) The sign-out process is visible.
4.2	!		37.) The sign-out process enables all relevant information to be viewed at once.
4.3		**10.)**	**38.) The sign-out process maintains a record of the sign-out process**
4.6	!	**11.)**	**39.) The sign-out process is quick to complete.**

NOTE: Latent needs are denoted by ! Importance ratings are the average of the ratings of 16 participants.

Step 2. Identification of metrics

The second step of Phase I involved the identification of metrics based on the need statements and results from Step 1. Metrics describe the output of a product or a system in measurable detail from a designer's perspective. To create metrics, the needs were organized by their importance rating, as shown in Table 3.3. Since some needs required more than one metric to be fully addressed, a total of 31 metrics were developed, 6 objective and 25 subjective (see Table 3.4). Objective performance measures include time, number of skipped items, number of incorrect entries, and percentages, while subjective measures include user ratings of perceived performance and satisfaction. These 31 metrics were subsequently developed into a survey (see Appendix F) that the research team used to collect performance data from the surgical staff during an actual surgical procedure in Phase II.

Table 3.3
Needs organized by importance rating

Avg. User Rating	Latent Needs	Need #	
4.9	!	9	The sign-out process ensures that sign-outs are completed before surgical staff leave the OR.
4.9	!	17	The sign-out process is simple.
4.9		28	The sign-out process helps to reduce errors made in the OR.
4.8		4	The sign-out process is concise.
4.8		8	The sign-out process ensures that the sign-out process is completed at the end of every surgery.
4.8		19	The sign-out process is easy to use.
4.7	!	3	The sign-out process is standardized across all surgical procedures.
4.7	!	26	The sign-out process ensures that participants understand what information is required to complete the sign-out process.
4.7		34	The sign-out process ensures that users complete the sign-out process with every patient.

4.6	!	2	The sign-out process organizes information logically.
4.6	!	10	The sign-out process ensures that surgical staff complete the sign-out process.
4.6	!	14	The sign-out process supports effective communication among surgical staff.
4.6	!	15	The sign-out process promotes effective communication.
4.6	!	20	The sign-out process helps participants to remember to complete the sign-out process.
4.6	!	24	The sign-out process notifies users when the sign-out procedure is completed.
4.6	!	39	The sign-out process is quick to complete.
4.5	!	18	The sign-out process presents information that is easy to read.
4.5	!	30	The sign-out process encourages consistent use.
4.5	!	33	The sign-out process encourages users to complete sign-outs before leaving the OR.
4.4		12	The sign-out process integrates well with the existing workflow.
4.4		21	The sign-out process ensures that all surgical staff members are aware of their responsibilities for the patient in the OR.
4.4	!	23	The sign-out process enables errors to be detected easily.
4.4		25	The sign-out process makes the surgical staff aware of the sign-out process.
4.4		31	The sign-out process encourages user to complete the sign-out process.
4.4	!	35	The sign-out process encourages alertness with respect to the sign-out process.
4.3	!	29	The sign-out process notifies users when a step in the sign-out process has been skipped.
4.3		38	The sign-out process maintains a record of the sign-out process
4.2	!	13	The sign-out process can be picked up easily where it was stopped due to an interruption.
4.2		27	The sign-out process ensures that users understand the benefits of the sign-out process.
4.2	!	37	The sign-out process enables all relevant information to be viewed at once.
4.1	!	5	The sign-out process is accessible from every location in the OR.
4.1		32	The sign-out process encourages inexperienced users to complete the sign-out process.
4.1		36	The sign-out process is visible.
4	!	16	The sign-out process ensures that the sign-out process is discussed by all users.
4		22	The sign-out process promotes understanding of the importance of checklists.
3.9	!	11	The sign-out process supports emergency cases.
3.6	!	6	The sign-out process is accessible at any time.
3.5	!	1	The sign-out process helps users to be aware of their roles in the sign-out process.
3.4	!	7	The sign-out process is readily available when surgical staff enter the OR.

Table 3.4

Translation of the need statements into metrics

Metric #	*Need #*	*Avg. User Rating*	*Latent Need*	*Metrics*	*Measurement Tools*
1	8,9,10, 31,33	4.9	!	Workload: Performance	Item No.4, NASA-TLX: How successful were you in accomplishing what you were asked to do?
2	17	4.9	!	Ease-of-use	Question No.3, SUS: I thought the system was easy to use.
3	17	4.9	!	Time to start the sign-out process	Objective measure: Seconds
4	28	4.9		Number of sign-out process steps performed incorrectly (commission errors)	Objective measure: Number
5	4	4.8		Workload: Mental demand	Item No.1, NASA-TLX: How mentally demanding was the task?
6	19	4.8		Ease-of-use	Question No.3, SUS: I thought the system was easy to use.
7	3	4.7	!	User rating of standardization	Question No.6, SUS: I thought it was too much inconsistency in this system.
8	26	4.7	!	User rating of ability to ensure that participants understand what information is required to complete the sign-out process	Question No.9, SUS: I felt very confident using the system.
9	26	4.7	!	Number of incorrect entries on sign-out document	Objective measure: Number
10	34	4.7		User satisfaction with encouragement of users to complete the sign-out process with every patient	Item No.1, NASA-TLX: How mentally demanding was the task?
11	2	4.6	!	User rating of information organization	Question No.6, SUS: I thought it was too much inconsistency in this system.
12	14,15	4.6	!	User rating of effectiveness of communication among surgical staff	Subjective measure: 1-5 scale

13	20,21,24,25,35,1	4.6,4.4,4.6,4.4,4.4,3.5	!	User rating of the degree to which the sign-out process ensures situation awareness	Subjective measure: 1-5 scale
14	39	4.6	!	Time taken to complete the sign-out process	Seconds
15	18,36	4.1,4.5	!	User rating of the ease of reading the sign-out process	Question No.3, SUS: I thought the system was easy to use.
16	18,36	4.5	!	Workload: Physical demand	Item No.2, NASA-TLX: How physically demanding was the task?
17	30	4.5	!	Encouragement of consistent use	Question No.1, SUS: I think that I would like to use this system frequently.
18	12	4.4		User satisfaction with the degree to which the sign-out process integrates with the existing workflow	Question No.5, SUS: I found the various functions in this system were well integrated.
19	23	4.4	!	User satisfaction with the degree to which the sign-out process helps the team to detect errors	Subjective measure: 1-5 scale
20	31	4.4		Encouragement to complete the sign-out process	Question No.1, SUS: I think that I would like to use this system frequently.
21	29	4.3	!	Number of sign-out items that are skipped (omission errors)	Objective measure: Number
22	38	4.3		User rating of the degree to which the sign-out process maintains a record of the sign-out process	Subjective measure: 1-5 scale
23	13	4.2	!	User satisfaction with the ease of pulling up the sign-out process after an interruption	Question No.3, SUS: I thought the system was easy to use.
24	22,27	4.2		User rating of the degree to which the sign-out process ensures that users understand the benefits of the sign-out process	Subjective measure: 1-5 scale
25	37	4,4.2	!	User satisfaction with the degree to which the sign-out process enables relevant information to all be viewed at once	Subjective measure: 1-5 scale

26	5	4.1	!	User satisfaction with the accessibility of the sign-out process from every location	Subjective measure: 1-5 scale
27	32	4.1		User satisfaction with the degree to which the sign-out process enables inexperienced users to use the sign-out process	Question No.7, SUS: I would imagine that most people would learn to use this system very quickly.
28	16	4	!	Percentage of time that the sign-out process is not discussed	Objective measure: %
~~29~~	~~11~~	~~3.9~~	~~!~~	~~User satisfaction with the degree to which the sign-out process supports emergency cases~~	~~Subjective measure: 1-5 scale~~
~~30~~	~~6~~	~~3.6~~	~~!~~	~~User rating of the degree to which the sign-out process is accessible at all times~~	~~Subjective measure: 1-5 scale~~
~~31~~	~~7~~	~~3.4~~	~~!~~	~~User rating of their satisfaction with the availability of the sign-out process when surgical staff enter the OR~~	~~Subjective measure: 1-5 scale~~

Step 3. Concept generation, selection, design and refinement using PowerPoint

Step 3 of Phase I began with the development of concepts for a user-centered sign-out process to be delivered on two platforms; a desktop computer and a tablet. Three concepts, a checklist-based sign-out process, a one-screen sign-out process, and a multiple-screen sign-out process, were developed based on the results from Phase I and the current sign-out process used at Greenville Memorial Hospital (GMH), shown in Figure 3.1. They were subsequently prototyped using PowerPoint and shown to surgical professionals at GMH for feedback before a sign-out process was developed as a web application. The goal of this phase was to design, test, and refine the concept to create a

final working sign-out process web application that was presented on a desktop computer and a tablet in an OR in Phase II.

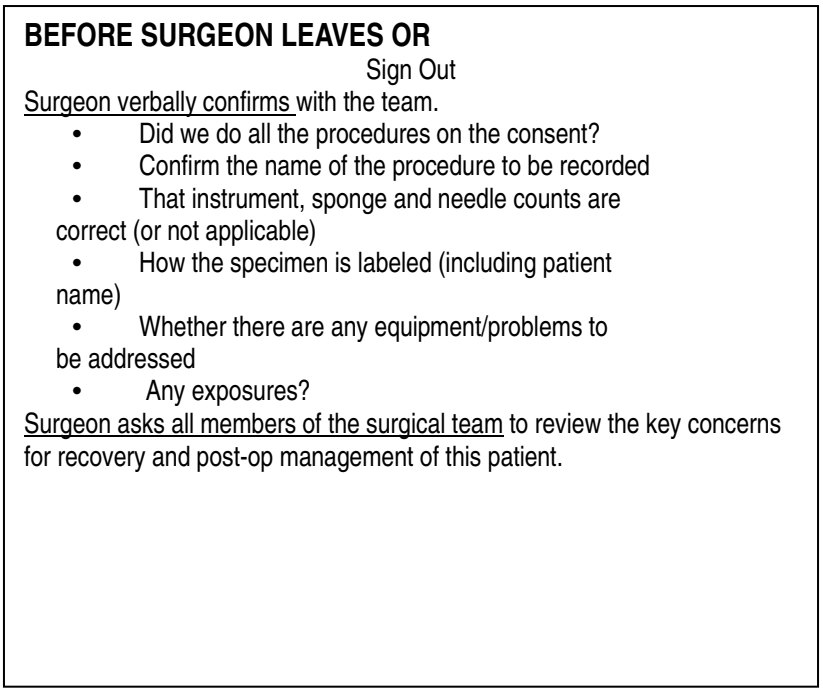


Figure3.1. Current Sign-Out Process (GMH version)

I. Checklist-based sign-out process

Similar to the original purpose of the WHO surgical safety checklist (WHO, 2008), the checklist-based sign-out process concept was designed so that each item on it must be checked off using the appropriate box. For convenience, all items appeared on one screen. Users were not allowed to move on to the next item unless they checked off the current one. Users were able to review every item before exiting the sign-out process. Once every item was checked off, the sign-out process was completed. Figure 3.2 shows the design of Concept I.

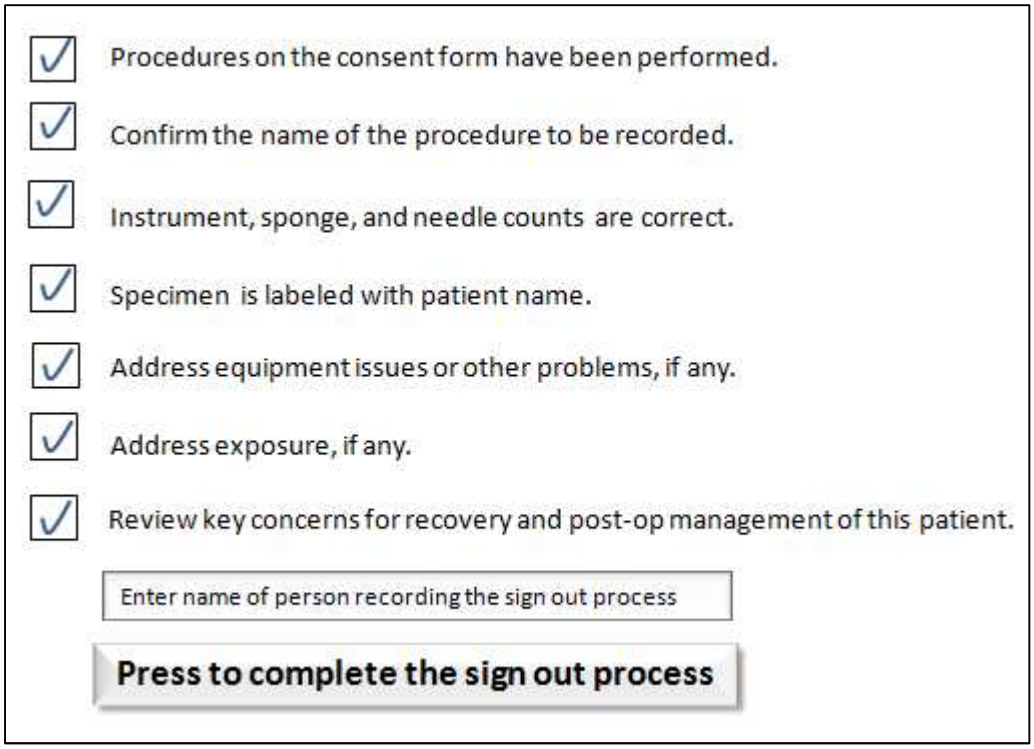


Figure 3.2. Concept I: Checklist Based Sign-Out Process

II. One-screen sign-out process

Similar to Concept I, the one-screen sign-out process concept enabled users to view every sign-out item on one screen. Users were able to review each item before exiting the sign-out process. Each sign-out process item in this design was addressed with a yes or no. Text boxes were included for users to describe issues and concerns they had during the process. The application did not allow users to move to the next item without completing the current one. Users could not exit the sign out process without completing every item. Figure 3.3 shows the design of Concept II.

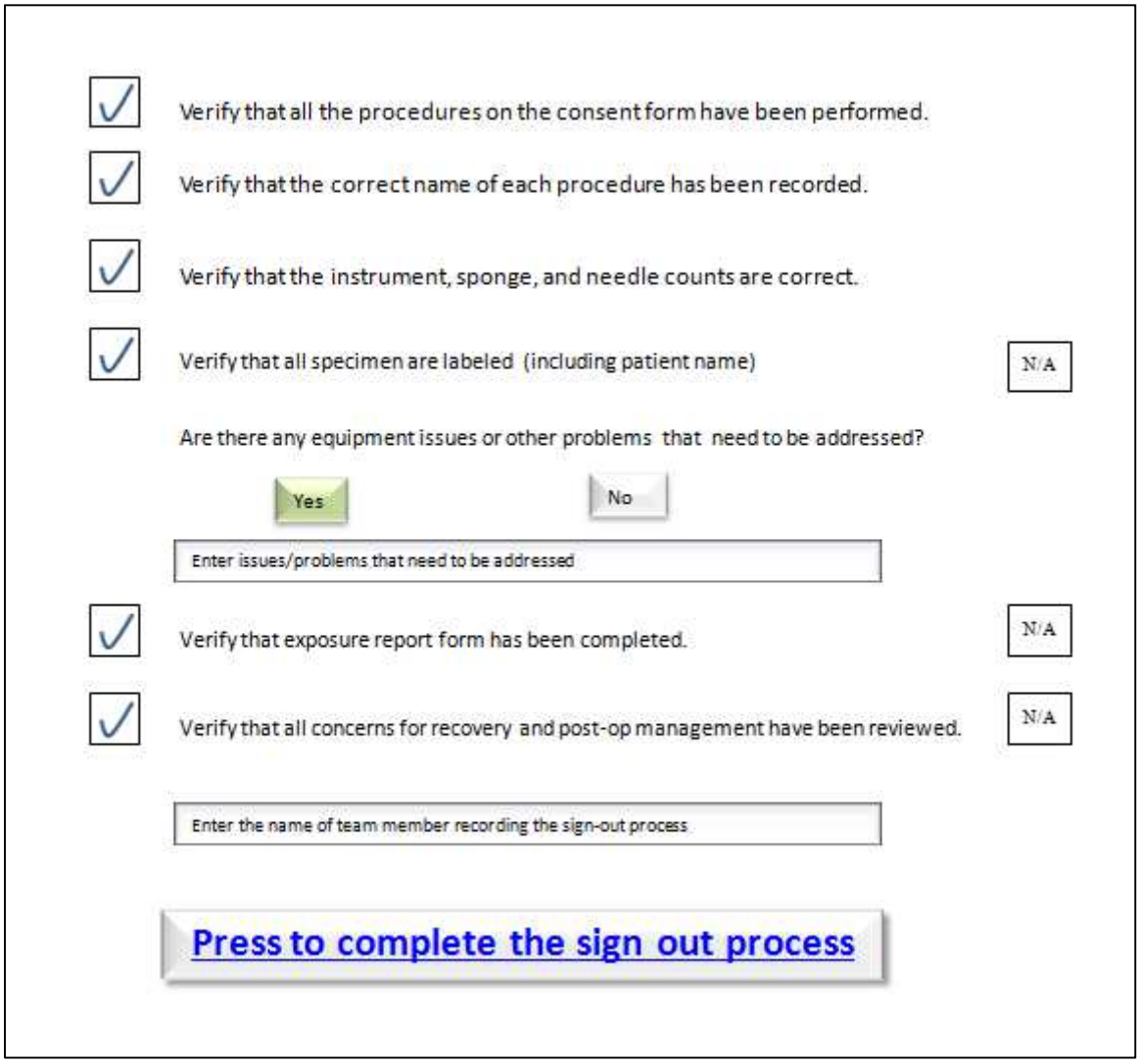


Figure 3.3. Concept II: One-Screen Sign-Out Process

III. Multiple-screen sign-out process

Similar to Concept II, each sign-out process item in this concept involved a yes or no answer and a textbox. However, this concept displayed only one sign-out process item per screen. This approach was designed to help users focus on each item while completing the sign-out process. Users clicked the next

button to move to the next page and the back button to return to the previous page. Each page displayed the current page number next to the total number of pages to help the users know where they were in the process. Once the last sign-out process item was completed, they clicked 'submit' to exit the sign-out process.

Figure 3.4 shows the design of concept III.

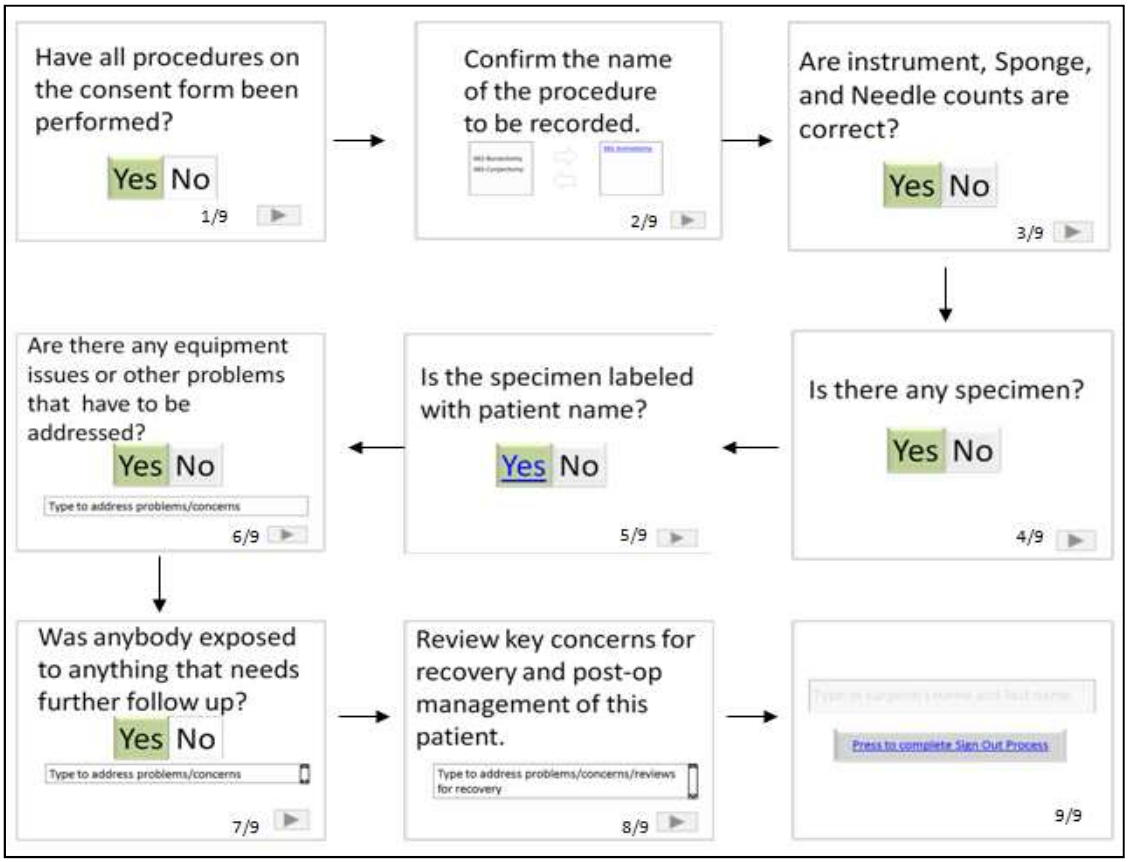


Figure 3.4. Concept III: Multiple-Screen Sign-Out Process

Results

Feedback from healthcare professionals at Greenville Memorial Hospital indicated that concepts I and II were preferred to concept III. The strengths of the two concepts were their simplicity, their checklist structure, their being limited to one-screen, and the text box for issues and concerns. These concepts were further refined and combined using PowerPoint prototypes based on user feedback. The final prototype, the PowerPoint of which is shown in Figure 3.5, was developed as a web application using the *php* programming language. The *MySQL* database management system was used to build a database structure and save the data, to inspect status, and to work with the data records.

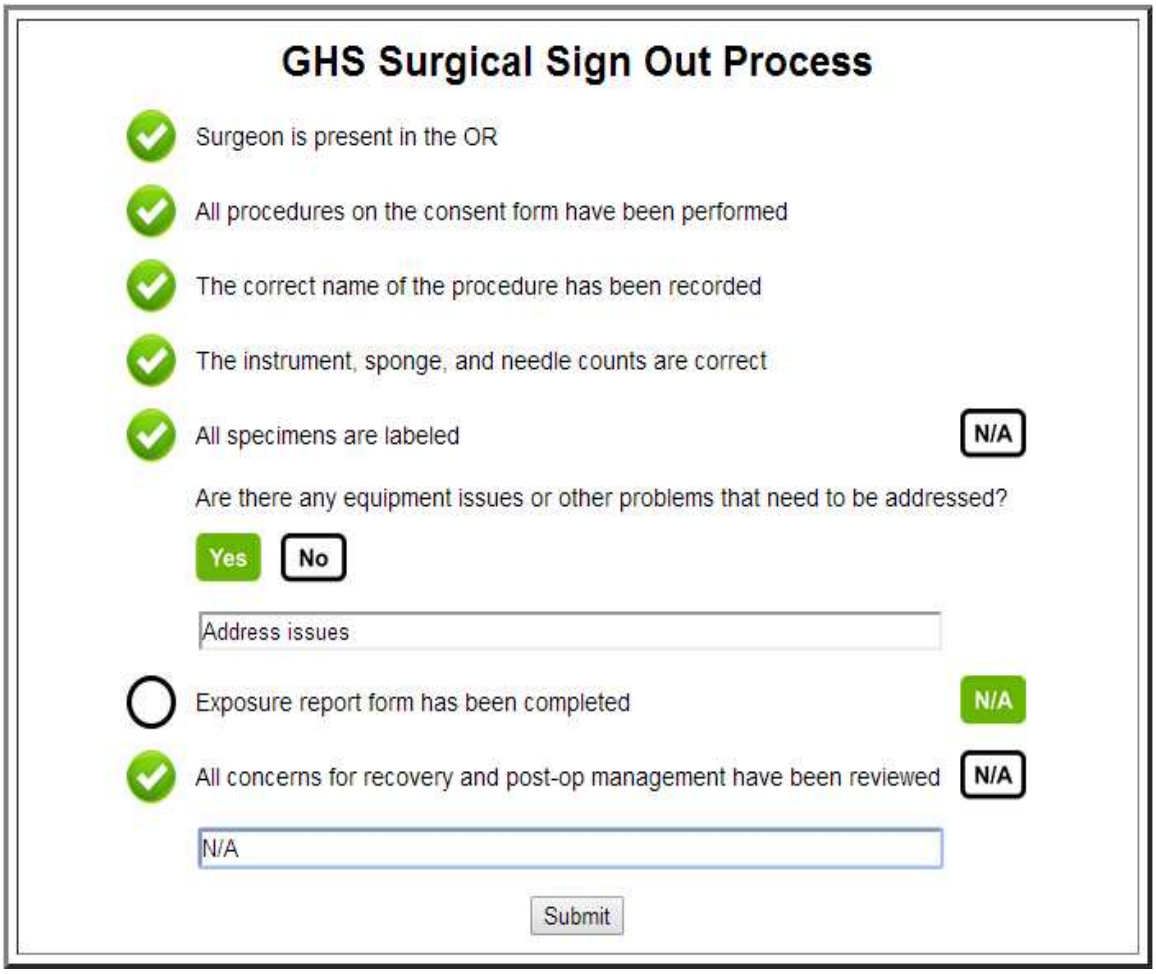


Figure3.5. Final Sign-Out Process Prototype

Upon IRB approval, a panel of medical experts evaluated the web-based application prototypes, and prospective users evaluated the interface designs to refine them. After these refinements, the sign-out process in the web application, shown in Figure 3.6, was implemented on a desktop and a tablet in the OR in Phase II.

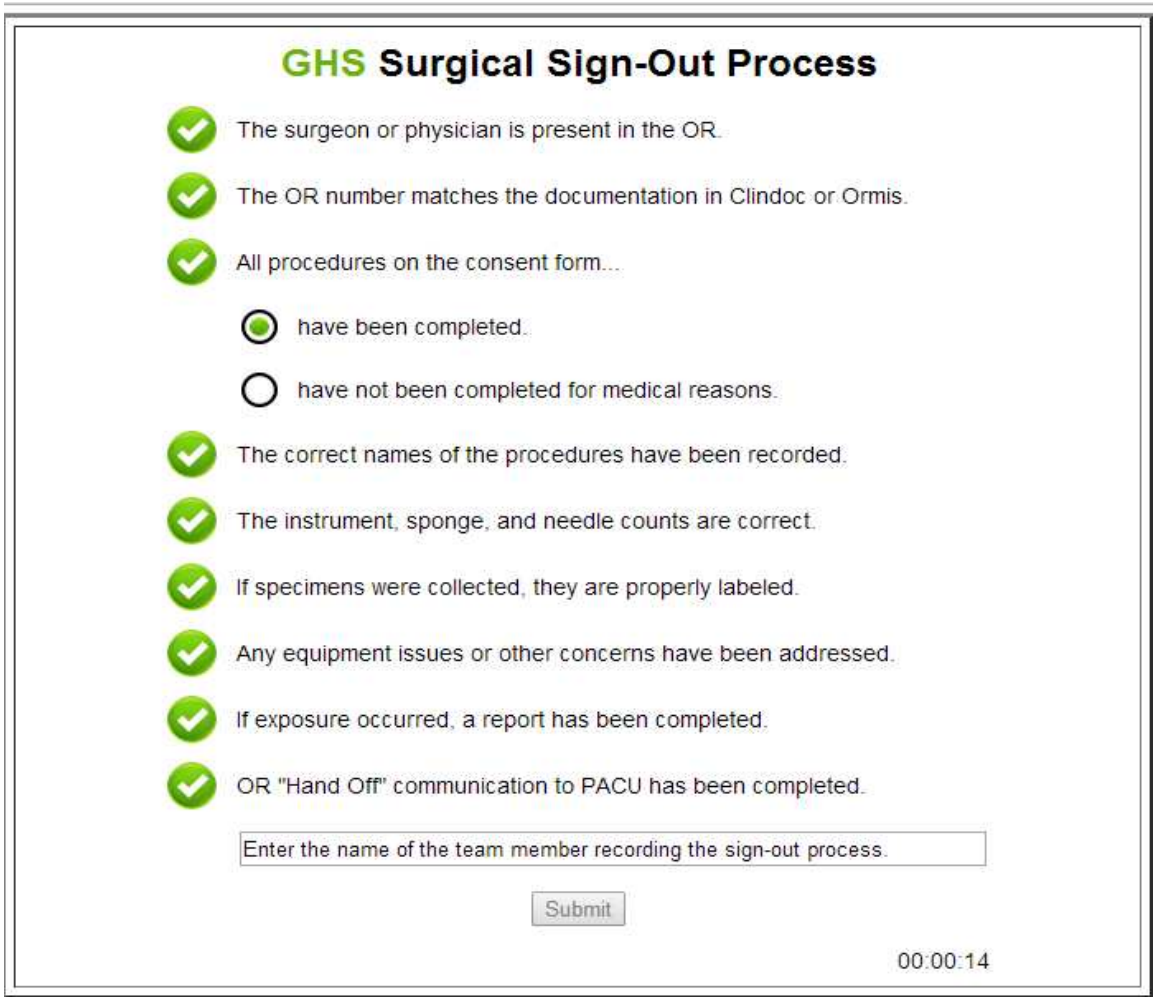


Figure3.6. Sign-out process WebApp

CHAPTER IV

HYPOTHESES

Step 4 of Phase II explored seven primary hypotheses:

1. The total time taken for the sign-out process will be different for the current sign-out process on the desktop displayed using a projector than for the two WebApp platforms.

   Since the proposed web application was designed for users to interact with the process, unlike the current one, the current process is expected to be different in terms of amount of time to initiate and complete the sign-out process.

2. The number of errors will be different for the current sign-out process on the desktop displayed using a projector than for the two WebApp platforms.

   Since the proposed web application was designed to reduce the number of errors made during the sign-out process in the OR, it is hypothesized that the current process will be different in terms of the number of the sign-out steps performed incorrectly, sign-out items that are skipped, and times that the sign-out process is not discussed.

3. The workload scores will be different for the current sign-out process on the desktop displayed using a projector than for the two WebApp platforms.

   Since research has shown that a method of presentation without an intuitive organizational scheme can increase workload and frustration

(Otter & Johnson, 2000), the current sign-out process is expected to be different in terms of workload.

4. The system usability scores will be different for the current sign-out process on the desktop displayed using a projector than for the two WebApp platforms.

   Since research has shown that an interface design without conceptual and intuitive information organization causes users to become disoriented and frustrated and lose interest (McDonald and Stevenson, 1998), it was hypothesized that the current sign-out process will be different in terms of usability scores.

5. The preference questionnaire scores will be different for the current sign-out process on the desktop displayed using a projector than for the two WebApp platforms.

   Since the web application was designed to meet the need expected by users, it is expected that the preference scores of the current sign-out process will be different from the WebApp platforms. Table 4.1 relates this hypothesis to each preference questionnaire item resulting from the analysis of needs in Step 2 of Phase I, identification of metrics.

Table 4.1
Hypotheses for preference questionnaire items

Usability Item	*Current sign-out process on the desktop*	*Sign-out process WebApp on the desktop or the tablet*
User rating of effectiveness of communication among surgical staff	Lower	Higher
User rating of the degree to which the sign-out process ensures situation awareness	Lower	Higher
User satisfaction with the degree to which the sign-out process helps the team to detect errors	Lower	Higher
User rating of the degree to which the sign-out process maintains a record of the sign-out process	Lower	Higher
User rating of the degree to which the sign-out process ensures that users understand the benefits of the sign-out process	Lower	Higher
User satisfaction with the degree to which the sign-out process enables relevant information to be viewed all at once	Lower	Higher
User satisfaction with the accessibility of the sign-out process from every location	Lower	Higher

6. The workload scores for the sign-out process using the WebApp on the tablet will be different than for the sign-out process using the WebApp on the desktop.

   Since research has shown that the flat keyboard and input interface of a tablet is more mentally demanding, more frustrating, and requires more effort to use than the desktop computer interface (Chaparro, Phan, Siu, & Jardina, 2014), it is hypothesized that the sign-out process WebApp on the desktop will be different in terms of workload scores from the sign-out process WebApp on the tablet.

7. The system usability scores for the sign-out process using the WebApp on the tablet will be different than for the sign-out process using the WebApp on the desktop.

   Since research has shown that mobile devices are less efficient than traditional desktop computers in certain aspects, such as response speed and input accuracy

(Findlater & Wobbrock, 2012), it is hypothesized that the sign-out process WebApp on the tablet will be different in terms of usability scores from the sign-out process WebApp on the desktop.

CHAPTER V

RESEARCH DESIGN

Step 4. Concept Testing

The final step of the user-centered design methodology used in this research was concept testing. In this step, the concept that was selected and refined in Step 3, concept generation, was tested in operating rooms with 18 representative circulating nurses serving as members of surgical teams. These healthcare professionals were recruited via email or word-of-mouth. A helper, graduate student specializing in usability, assisted in the data collection.

5.1. Testing Environment

The sign-out process took place in the operating rooms at Greenville Memorial Hospital at the end of surgical procedures.

5.2. Personnel and Their Roles

Each sign-out process session involved the circulating nurse on a surgical team responsible for leading, participating and completing the sign-out process. The helper assisted in timing and recording the number of skipped sign-out items and the number of times that the sign-out process was not discussed. The researcher, as an observer, administered the study, instructed participants about the subjective measures and the

user rankings of the platforms and recorded the number of incorrect sign-out steps made in the OR.

5.3. Experimental Design

This study was a within-subject design with one factor tested at three levels, the current sign-out process on the desktop also displayed using a projector, the sign-out process using the web application (WebApp) on the desktop also displayed using a projector, and the sign-out process using the WebApp on the tablet. Each sign-out process platform was used by each participant. The study was conducted in three sessions, one for each sign-out process platform. The sign-out process platforms were assigned using the 18 counterbalanced orders presented in Table 5.1 to control for order effects. Each circulating nurse was instructed to complete the sign-out process associated with the given platform and then repeated this process two more times within the same day.

Table 5.1
Counterbalanced assignment order for sign-out process platform

Team #		**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
Platform Type	*Platform 1*	3	3	2	2	1	1	3	1	2	3	1	2	3	2	2	3	1	1
	Platform 2	2	1	1	3	2	2	1	3	1	1	2	3	2	1	3	2	3	3
	Platform 3	1	2	3	1	3	3	2	2	3	2	3	1	1	3	1	1	2	2

(1—Current sign-out process, 2—WebApp on the desktop, 3—WebApp on the tablet)

5.4. Independent Variable

The independent variable in this study was the sign-out process platform studied at three levels;

1. The current sign-out process on the desktop computer also displayed using a projector,
2. The sign-out process using the WebApp on the desktop computer also displayed using a projector,
3. The sign-out process using the WebApp on the tablet.

5.5. Dependent Variables

The dependent variables were the objective and subjective measures. The objective measures are listed below:

1. The time taken by the team to initiate the sign-out process measured using a timer. The timer was activated when the participant began to retrieve the sign-out process and was stopped when the sign-out process was ready to use.
2. The time taken by the team to complete the sign-out process measured using a timer. The timer was activated when the sign-out process was ready to use and was stopped when the team indicated that they have completed the process.
3. The number of sign-out steps performed incorrectly in the OR, recorded by the researcher.
4. The number of sign-out items that were skipped as manually tracked and recorded by the helper.

5. The number of times that sign-out items were not discussed by users recorded by the helper.

The subjective measures are as follows.

1. Participants' perceived usability of each platform

   The perceived usability of each sign-out process platform was measured using two: the System Usability Scale (SUS) (Brooke, 1996) and the sign-out process questionnaire. The SUS contained 10 items, based on a 5-point Likert scale (see Appendix D).

2. Perceived workload

   The perceived workload was measured using the NASA-Task Load Index (NASA-TLX) (Hart, S.G., & Staveland, L.E., 1988) (see Appendix E). The scores on all the subscales including mental demand, physical demand, temporal demand, performance, effort and frustration were used to calculate the overall workload of each sign-out process platform.

3. Preference questionnaire

   The preference questionnaire was measured using the survey seen in Appendix F. The scores on all the items including communication effectiveness, situation awareness, error detection, maintaining records, understanding the benefits, enabling information to be viewed at once and accessibility from every location were used to calculate the overall preference questionnaire scores.

4. Preference ranking

A ranking of the preferences for the three sign-out process platforms was obtained using the preference ranking questionnaire seen in Appendix G.

Figure 5.1 below shows the independent variable and dependent variables for this study.

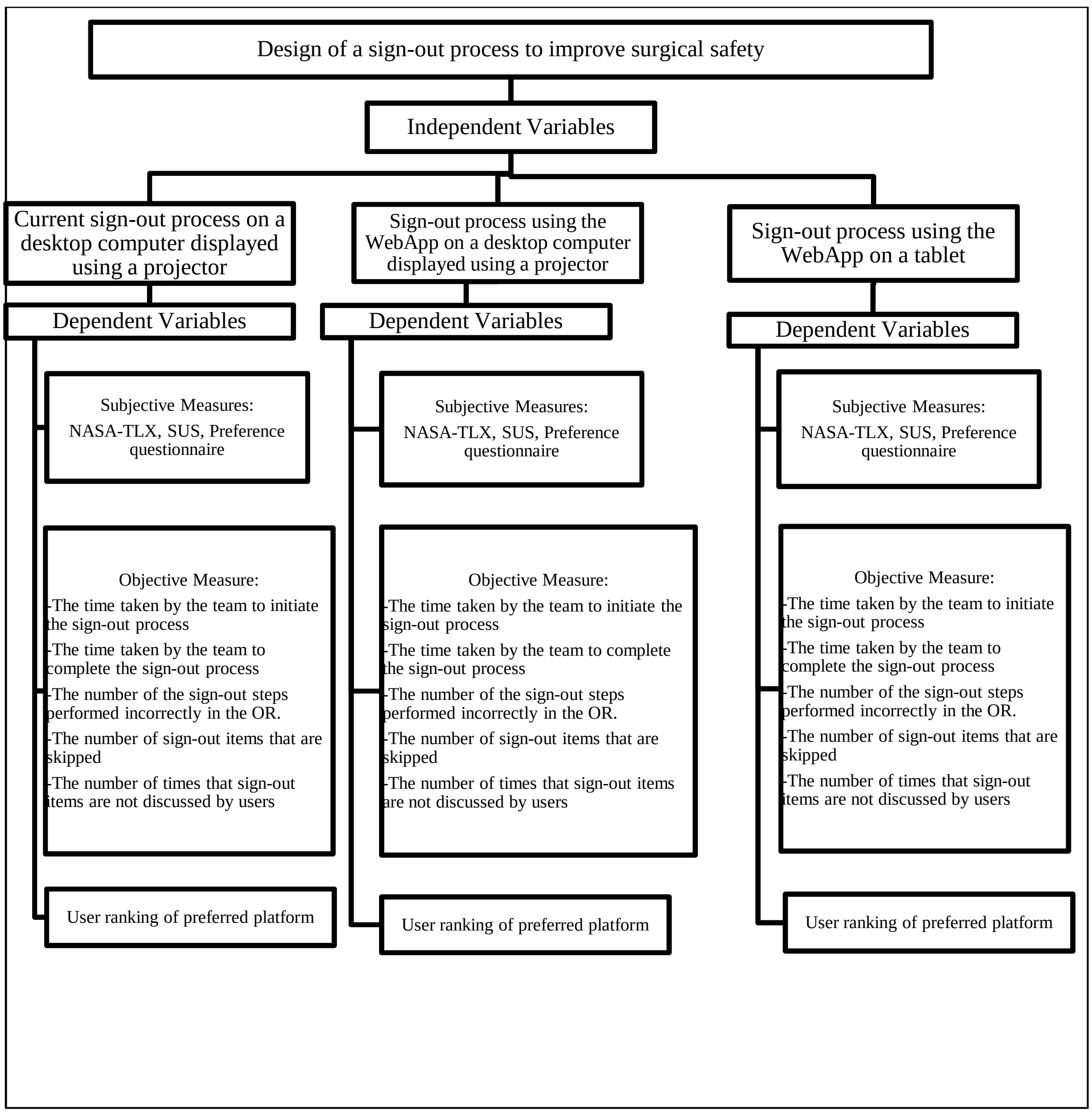


Figure 5.1. Structure of Independent Variable and Dependent Variables

5.6. Procedure

Before the scheduled arrival of the participants in the ORs at Greenville Memorial Hospital, the helper was trained on his respective roles for the sign-out process platforms and measurement methods. The helper was also provided with a consent form to show the participants if they asked for it. On the first surgical procedure of data collection day, the participants were greeted by the researcher and briefed on the purpose of the study and the sign-out process platform they were to be using at the end of the surgical procedure. The participants then read and signed the informed consent form. On the first surgical procedure as well as the second and third procedures, they then participated in a sign-out process event using the appropriate sign-out process platform. The sign-out process was activated, and the participants were asked to process and complete the sign-out items by interacting with the platform. Each session lasted approximately 15 minutes, including training. After the completion of a sign-out process, the participants were then asked to complete the NASA-TLX workload questionnaire, the System Usability Scale questionnaire, and the sign-out process survey. This step marked the end of a session. At the end of the third session, the participants were asked to complete a survey ranking the three sign-out process platforms (see Appendix G).

Semi-structured interviews were conducted after participants completed each sign-out process platform. Each participant was asked whether or not they preferred the assigned sign-out process platform. Content analysis was used to sort the participant

responses into categories to better understand the concerns and preferences of the participants after completing each sign-out process. Participant responses were recorded as handwritten notes by the research team and then transcribed into a word processor document. Each interview, which took approximately 2 minutes, consisted of one or more interviewers discussing checklist needs with a single interviewee.

5.7. Proposed Statistical Analysis

The data collected was analyzed for normality and homogeneity of variance. Some of these characteristics were not satisfied so the data were transformed accordingly. IBM- SPSS 19 was used to conduct a one-way within-subject analysis of variance (ANOVA) to determine the presence of statistically significant differences along the dependent measures on the three sign-out process platforms. A post-hoc LSD test was conducted to determine the locus of any significant differences. A non-parametric test, specifically, a Friedman's test, followed by a Wilcoxon's signed-rank test, was used for analyzing data that did not satisfy the assumptions of analysis of variance.

CHAPTER VI

RESULTS

The performance of the sign-out process platforms was measured using both objective and subjective measures. These datasets, collected through observations of the process in the ORs at Greenville Memorial Hospital, were analyzed based on the dependent variables.

Objective Measures

The objective measures include

1. Time taken by the participant to initiate and complete the sign-out process
2. The number of sign-out steps performed incorrectly in the OR
3. The number of sign-out items skipped
4. The number of times that sign-out items were not discussed

Time taken by the participant to initiate and complete the sign-out process

The time taken to initiate the sign-out process was measured by a timer, beginning when the participant began to retrieve the sign-out document and ending when the sign-out document was ready-to-use. The time taken to complete the sign-out process began at that point and ended when the team indicated that participants had completed the process. The normality assumption revealed that neither dataset violated the

normality assumption and that Levene's statistic for the homogeneity of variances assumption was satisfied.

The one-way ANOVA was subsequently applied to both datasets. The results revealed that differences in the time taken to initiate (M = 2.81, SD = 1.52, p = .009) and the time taken to complete (M = 60.87, SD = 32.36, p = .001) were statistically significant. The one-way ANOVA descriptive statistics of these statistical tests are provided in Table 6.1, while the one-way ANOVA results for the times are given in Table 6.2.

Table 6.1
One –way ANOVA descriptive statistics for the time (seconds)

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Time to initiate	Current	18	2.00	1.328	.313	1.34	2.66	1	6
	Desktop	18	3.50	1.724	.406	2.64	4.36	1	7
	Tablet	18	2.94	1.110	.262	2.39	3.50	1	5
	Total	54	2.81	1.518	.207	2.40	3.23	1	7
Time to Complete	Current	18	37.33	11.402	2.687	31.66	43.00	20	60
	Desktop	18	83.72	31.025	7.313	68.29	99.15	36	165
	Tablet	18	61.56	32.140	7.575	45.57	77.54	32	168
	Total	54	60.87	32.364	4.404	52.04	69.70	20	168

Table 6.2
One-way ANOVA results for the time (seconds)

		Sum of Squares	df	Mean Square	F	Sig.
Time to initiate	Between Groups	20.704	2	10.352	5.204	.009
	Within Groups	101.444	51	1.989		
	Total	122.148	53			
Time to Complete	Between Groups	19380.037	2	9690.019	13.677	.000
	Within Groups	36134.056	51	708.511		
	Total	55514.093	53			

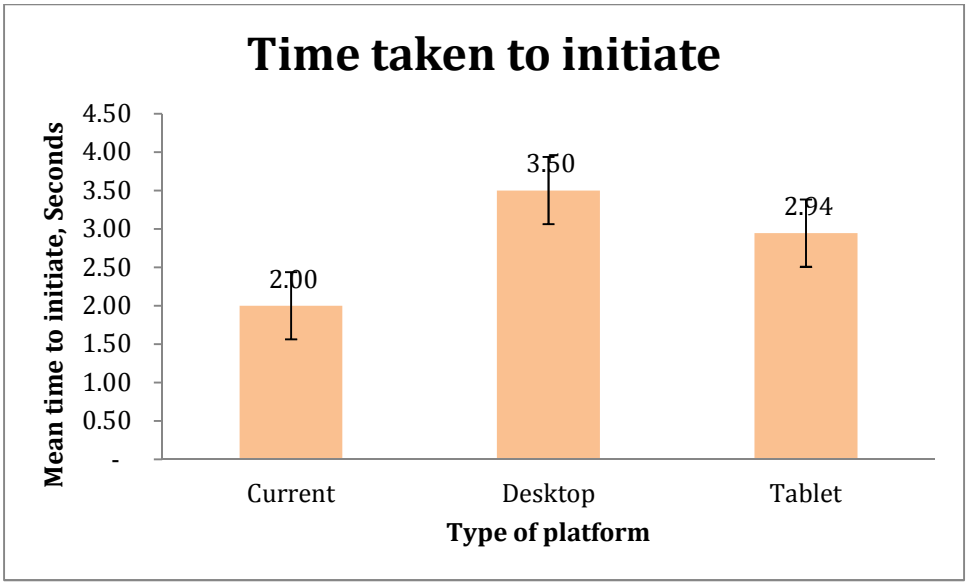
Post-hoc pairwise comparisons were then used across all sign-out process platforms, the results showing that the time taken to initiate for the current sign-out process on the desktop (M = 2) was less than both the WebApp on the desktop (M = 3.50, p = .002) and the WebApp on the tablet (M = 2.94, p = .050). There was no significant difference between the two WebApp platforms. The time taken to complete using the current system (M = 37.33) was also less than the WebApp on the desktop (M = 83.72, p = .001) and the tablet (M = 61.56, p = .009). The time taken to complete for the WebApp on the tablet was less than for the desktop (p = .016). The post-hoc pairwise comparison data are shown below in Table 6.3, with graphs showing the mean scores across all conditions being seen in Figures 6.1 and 6.2.

Table 6.3

Post-hoc pairwise comparisons for time

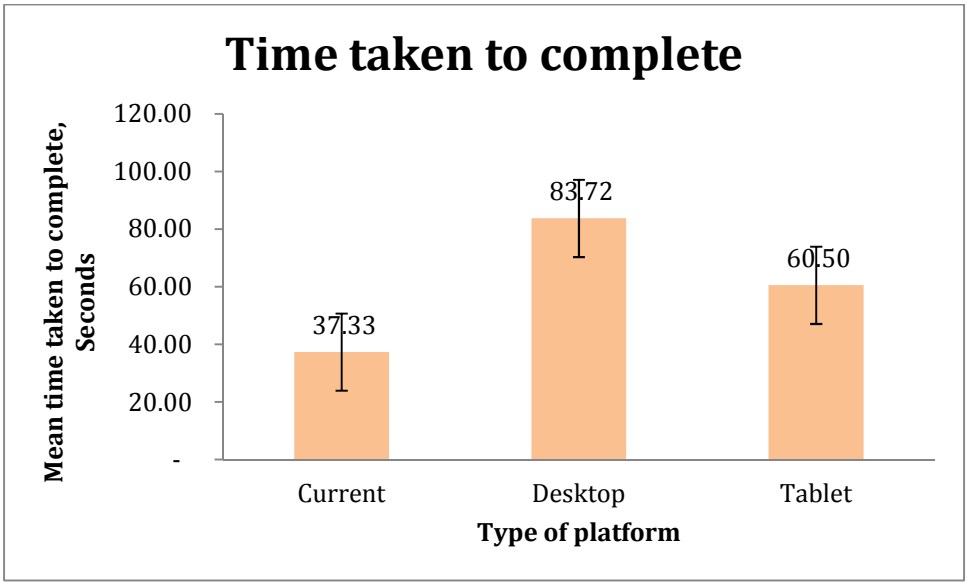
Dependent Variable	(I) platform	(J) platform	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Time to initiate	Current	Desktop	-1.500*	.470	.002	-2.44	-.56
		Tablet	-.944*	.470	.050	-1.89	.00
	Desktop	Current	1.500*	.470	.002	.56	2.44
		Tablet	.556	.470	.243	-.39	1.50
	Tablet	Current	.944*	.470	.050	.00	1.89
		Desktop	-.556	.470	.243	-1.50	.39
Time to Complete	Current	Desktop	-46.389*	8.873	.000	-64.20	-28.58
		Tablet	-24.222*	8.873	.009	-42.03	-6.41
	Desktop	Current	46.389*	8.873	.000	28.58	64.20
		Tablet	22.167*	8.873	.016	4.35	39.98
	Tablet	Current	24.222*	8.873	.009	6.41	42.03
		Desktop	-22.167*	8.873	.016	-39.98	-4.35

*The mean difference is significant at the 0.05 level.



Error bars: 95% CI

Figure 6.1 Mean time taken to initiate



Error bars: 95% CI

Figure 6.2 Mean time taken to complete

Number of sign-out steps performed incorrectly

The number of sign-out steps performed incorrectly in the OR was recorded by the researcher and helpers. The normality assumption revealed that these datasets were not normally distributed and remained so even after applying appropriate transformations.

As a result, a Friedman's test was applied, the results indicating no significant differences among the current sign-out process on the desktop, the sign-out process WebApp on the desktop, and the one on the tablet, χ^2 (2, N =18) = 2, p = .368. The Friedman's test statistics are provided in Table 6.4. Mean values for the number of sign-out steps performed incorrectly are displayed in the bar graph in Figure 6.3.

Table 6.4
Friedman's test statistics for number of sign-out steps performed incorrectly

N	18
Chi-Square	2.000
Df	2
Asymp. Sig.	.368

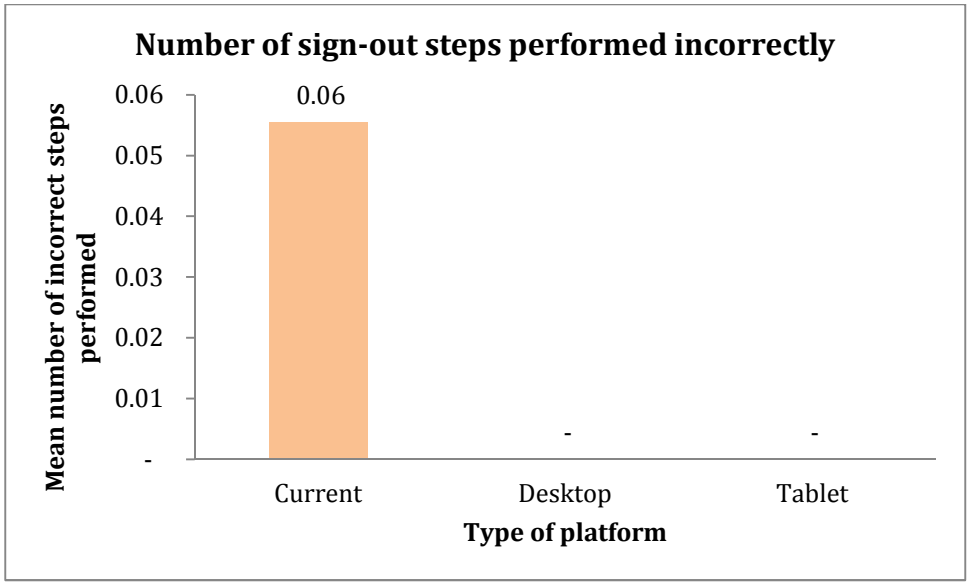


Figure 6.3 Mean number of sign-out steps performed incorrectly

Number of sign-out items skipped

The number of the sign-out items skipped was recorded by the researcher and helpers. The normally assumption test was then applied, the results indicating that the assumption was not met, and remained so even after applying appropriate transformations.

As a result, the Friedman's test was used to analyze the data. The results revealed that there was a statistically significant difference in the number of sign-out items skipped across the platforms, χ^2 (2, N =18) = 14.000, p = .001 as shown in Table 6.5.

Table 6.5
Friedman's test statistics for number of sign-out items skipped

N	18
Chi-Square	14.000
df	2
Asymp. Sig.	.001

A post-hoc pairwise comparisons test using Wilcoxon's signed-rank test revealed that the number of sign-out items skipped for the current sign-out process on the desktop was greater (*Mdn* = 0) than for the WebApp on the desktop (*Mdn* = 0), Z = -2 *p* = .001 and for the WebApp on the tablet (*Mdn* = 0), Z = -2.414, *p* = .016. The descriptive statistics for the number of sign-out items skipped are given in Table 6.6, and the results from the Wilcoxon's test are given in Table 6.7. A graph displaying the mean number of sign-out items skipped for all conditions is presented in Figure 6.4

Table 6.6

Descriptive statistics for number of sign-out items skipped

	N	Mean	Mean Rank	Std. Deviation	Minimum	Maximum	Percentiles		
							25th	50th (Median)	75th
Current_Number skipped items	18	.61	2.39	.916	0	3	.00	.00	1.00
Desktop_Number skipped items	18	.00	1.81	.000	0	0	.00	.00	.00
Tablet_Number skipped items	18	.00	1.81	.000	0	0	.00	.00	.00

Table 6.7

Pair-wise comparisons results from Wilcoxon's signed-rank test for sign-out items skipped

	Desktop_Number skipped items - Current_Number skipped	Tablet_Number skipped items - Current_Number skipped	Tablet_Number skipped items - Desktop_Number skipped
Z	-2.414	-2.414	.000
Asymp. Sig. (2-tailed)	.016	.016	1.00

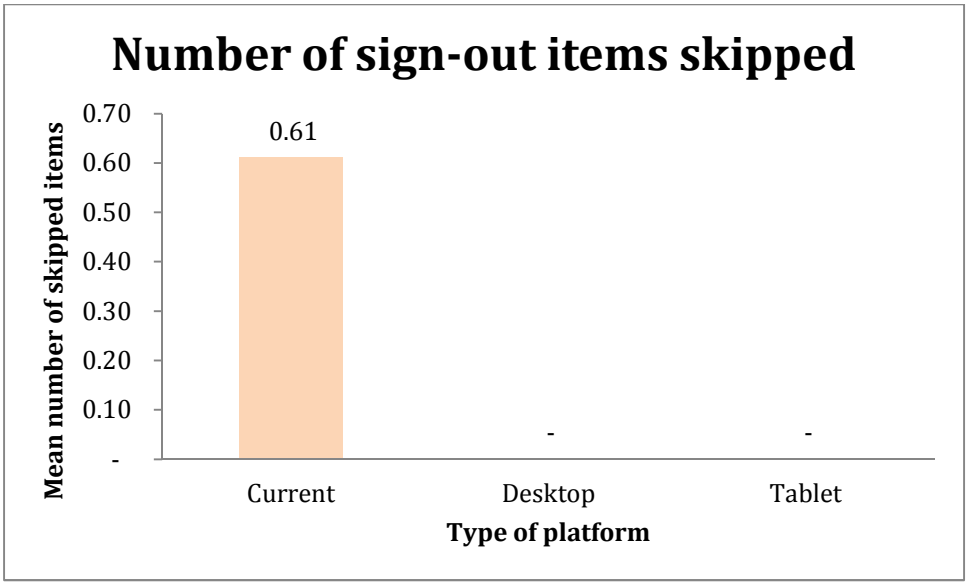


Figure 6.4 Mean number of times that sign-out items were skipped

Number of times sign-out items not discussed

The number of times that sign-out items were not discussed by the participants was recorded by the researcher and helpers. The data were used to analyze for normality, the results finding the normally assumption was not valid and they remained so even after applying appropriate transformations. As a result, the Friedman's test followed by the Wilcoxon's signed-rank test was used to analyze the data.

The Friedman's test revealed a statistically significant difference among the three platforms in the number of sign-out items not discussed, χ^2 (2, N =18) = 9.923, p = .007, as shown in Table 6.8.

Table 6.8
Friedman's test statistics for number of sign-out items discussed

N	18
Chi-Square	9.923
df	2
Asymp. Sig.	.007

The post-hoc pairwise comparisons test using Wilcoxon's signed-rank test revealed that the number of sign-out items not discussed using the current sign-out process on the desktop was greater (*Mdn* = 0) than the WebApp on the desktop (*Mdn* = 0), Z = -2.460, *p* = .014. No other differences were statistically significant. The descriptive statistics are provided in Table 6.9 and the results for the pair-wise comparisons using the Wilcoxon's signed-rank test are shown in Table 6.10. Mean values are displayed in the bar graph in Figure 6.5.

Table 6.9
Descriptive statistics for number of sign-out items not discussed

	N	Mean	Mean Rank	Std. Deviation	Minimum	Maximum	Percentiles		
							25th	50th (Median)	75th
Current_Number of no discussion	18	.61	2.36	.778	0	2	.00	.00	1.00
Desktop_Number of no discussion	18	.11	1.78	.323	0	1	.00	.00	.00
Tablet_Number of no discussion	18	.22	1.86	.548	0	2	.00	.00	.00

Table 6.10

Pairwise comparisons from Wilcoxon's signed-rank test for number of sign-out items not discussed

	Desktop_Number of no discussion - Current_Number of no discussion	Tablet_Number of no discussion - Current_Number of no discussion	Tablet_Number of no discussion - Desktop_Number of no discussion
Z	-2.460	-1.588	-.816
Asymp. Sig. (2-tailed)	.014	.112	.414

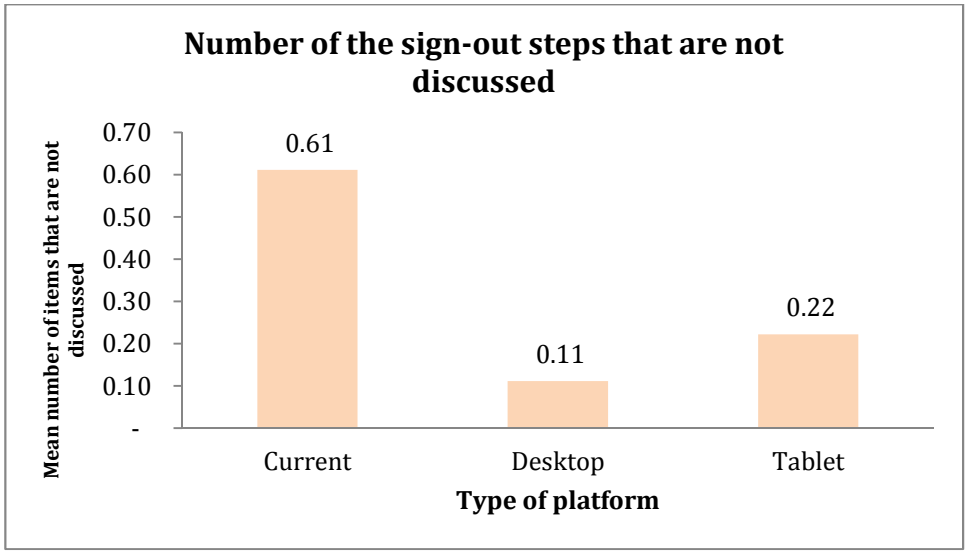


Figure 6.5 Mean numbers of times that sign-out items are not discussed

Subjective Measures

The subjective measures include

1. Perceived system usability (System Usability Scores)
2. Perceived workload (NASA-TLX)
3. Preference questionnaire scores and preference ranking

Perceived system usability (SUS)

The perceived usability of each sign-out process platform was measured using the System Usability Scale (SUS) questionnaire (Brooke, 1996). This standardized questionnaire contains 10-items, with the answers varying across a 5-point Likert scale (Appendix D). The SUS indices consist of 5 positively worded (questions 1, 3, 5, 7, 9) and 5 negatively worded ones, the responses to the latter (questions 2, 4, 6, 8, 10) being reverse coded. This questionnaire was administered after each participant completed each session. The data were analyzed, the results indicating that the SUS were normally distributed. The Levene's statistic for the homogeneity of variances indicated that this assumption was satisfied.

As a result, one-way ANOVA was subsequently applied. The results indicated that the differences in the mean values of the SUS were not significant (M = 81.80, SD = 14.37, p =.132), as shown in Tables 6.11 and 6.12. The mean values for the SUS are displayed in the bar graph in Figure 6.6.

Table 6.11

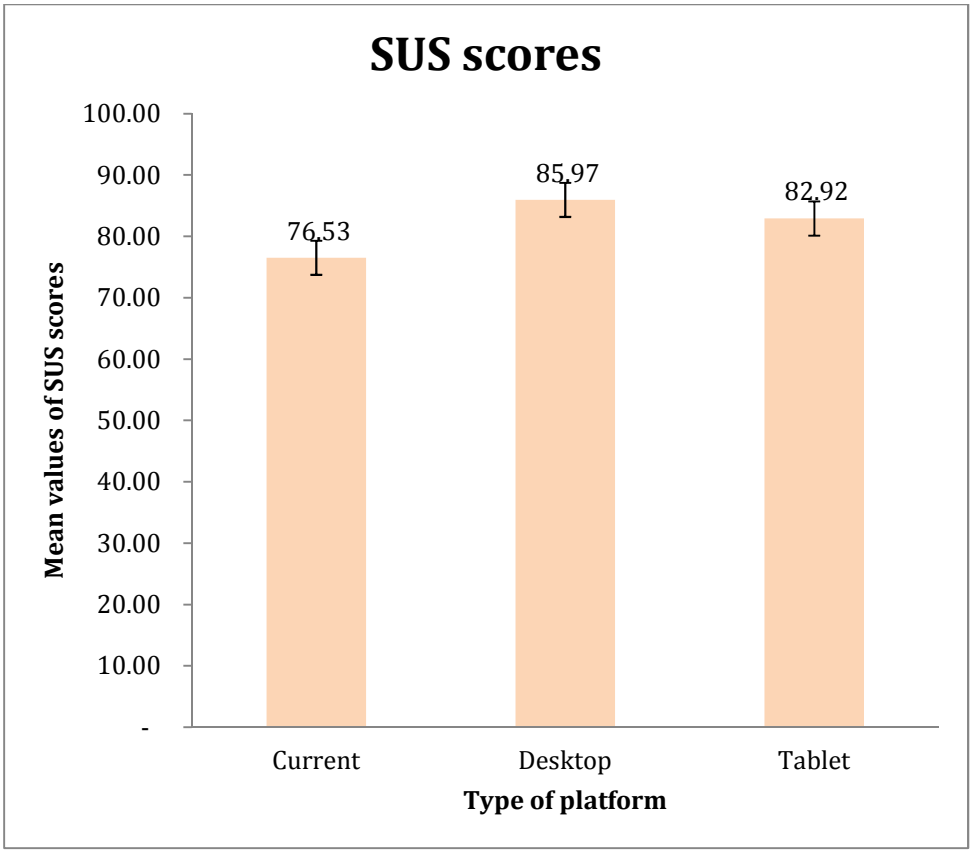
One-way ANOVA descriptive statistics for the SUS scores

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Current	18	76.5278	14.47967	3.41289	69.3272	83.7284	52.50	100.00
Desktop	18	85.9722	14.17171	3.34030	78.9248	93.0196	55.00	100.00
Tablet	18	82.9167	13.56493	3.19728	76.1710	89.6623	57.50	100.00
Total	54	81.8056	14.36893	1.95536	77.8836	85.7275	52.50	100.00

Table 6.12

One-way ANOVA results for SUS scores

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	836.111	2	418.056	2.110	.132
Within Groups	10106.597	51	198.169		
Total	10942.708	53			



Error bars: 95% CI

Figure 6.6 Mean score of system usability scale

Perceived workload

The perceived workload was measured after the participants completed each session using the NASA-TLX Index seen in Appendix E (Hart, S.G., & Staveland, L.E., 1988). The questionnaire uses a 7-point Likert scale, with the responses to question 4 (performance) reverse coded because it is worded differently from the rest. The scores on all the items including mental demand, physical demand, temporal demand, performance, effort and frustration were then used to calculate the overall workload. The data indicated that the normality assumption was not valid and remained so even after applying appropriate transformations.

As a result, the Friedman's test was applied to check significant differences among the three platforms. The results showed that differences for 2 of 6 workload indices were statistically significant: temporal demand, χ^2 (2, N =18) = 6.889, p = .032, and frustration, χ^2 (2, N =18) = 6.242, p = .044, as shown in Table 6.13.

Table 6.13

Friedman's test statistics for perceived workload

Mental demand	N	18
	Chi-Square	1.200
	df	2
	Asymp. Sig.	.549
Physical demand	N	18
	Chi-Square	2.889
	df	2
	Asymp. Sig.	.236
Temporal demand	N	18
	Chi-Square	6.889
	df	2
	Asymp. Sig.	.032
Performance	N	18
	Chi-Square	3.000
	df	2
	Asymp. Sig.	.223
Effort	N	18
	Chi-Square	2.667
	df	2
	Asymp. Sig.	.264
Frustration	N	18
	Chi-Square	6.242
	df	2
	Asymp. Sig.	.044

The post-hoc pairwise comparisons test using Wilcoxon's signed-rank test revealed that the temporal demand for the current sign-out process on the desktop was significantly higher (*Mdn* = 1) than for the sign-out process using the WebApp on the tablet (*Mdn* = 1), Z = -2.264, *p* = .032. However, there was no significant difference between the current system and the WebApp on the desktop, as well as between the WebApp on the tablet and the WebApp on the desktop. For frustration, the current sign-out process on the desktop scored significantly higher (*Mdn* = .50) than the sign-out process using the WebApp on the desktop (*Mdn* = 0), Z = -2.414, *p* = .044.

However, the results revealed no significant difference between the current system and the WebApp on the tablet as well as between the WebApp on the tablet and the WebApp on the desktop. The descriptive statistics are provided in Table 6.14 and the results for the pair-wise comparisons using a Wilcoxon's signed-rank test are shown in Table 6.15. The mean values for the workload indices of the sign-out process are displayed in the bar graph in Figure 6.7.

Table 6.14

Descriptive statistics for perceived workload

		N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
							25th	50th (Median)	75th
Mental demand	Current_Mental demand	18	.61	1.037	0	4	.00	.00	1.00
	Desktop_Mental demand	18	.28	.752	0	3	.00	.00	.00
	Tablet_Mental demand	18	.39	.608	0	2	.00	.00	1.00
Physical demand	Current_Physical demand	18	.44	.784	0	3	.00	.00	1.00
	Desktop_Physically demand	18	.11	.323	0	1	.00	.00	.00
	Tablet_Physically demand	18	.28	.461	0	1	.00	.00	1.00
Temporal demand	Current_Temporal demand	18	1.44	1.756	0	5	.00	1.00	2.25
	Desktop_Temporal demand	18	.56	1.199	0	4	.00	.00	.25
	Tablet_Temporal demanding	18	.83	.985	0	3	.00	1.00	1.00
Performance	Current_Performance	18	5.44	1.042	2	6	5.00	6.00	6.00
	Desktop_Performance	18	5.78	.647	4	6	6.00	6.00	6.00
	Tablet_Performance	18	5.83	.383	5	6	6.00	6.00	6.00
Effort	Current_Effort	18	4.89	1.676	0	6	4.75	5.50	6.00
	Desktop_Effort	18	5.67	.840	3	6	6.00	6.00	6.00
	Tablet_Effort	18	5.50	1.200	1	6	5.00	6.00	6.00
Frustration	Current_Frustration	18	1.17	1.654	0	5	.00	.50	2.00
	Desktop_ Frustration	18	.56	1.338	0	5	.00	.00	.25
	Tablet_ Frustration	18	.56	.856	0	3	.00	.00	1.00

Table 6.15

Pairwise comparisons from Wilcoxon's signed-rank results test for perceived workload

		Desktop - Current	Tablet - Current	Tablet - Desktop
Temporal demand	Z	-1.654	-2.264	-.837
	Asymp. Sig. (2-tailed)	.098	.024	.403
Frustration	Z	-2.414	-1.725	-.214
	Asymp. Sig. (2-tailed)	.016	.084	.831

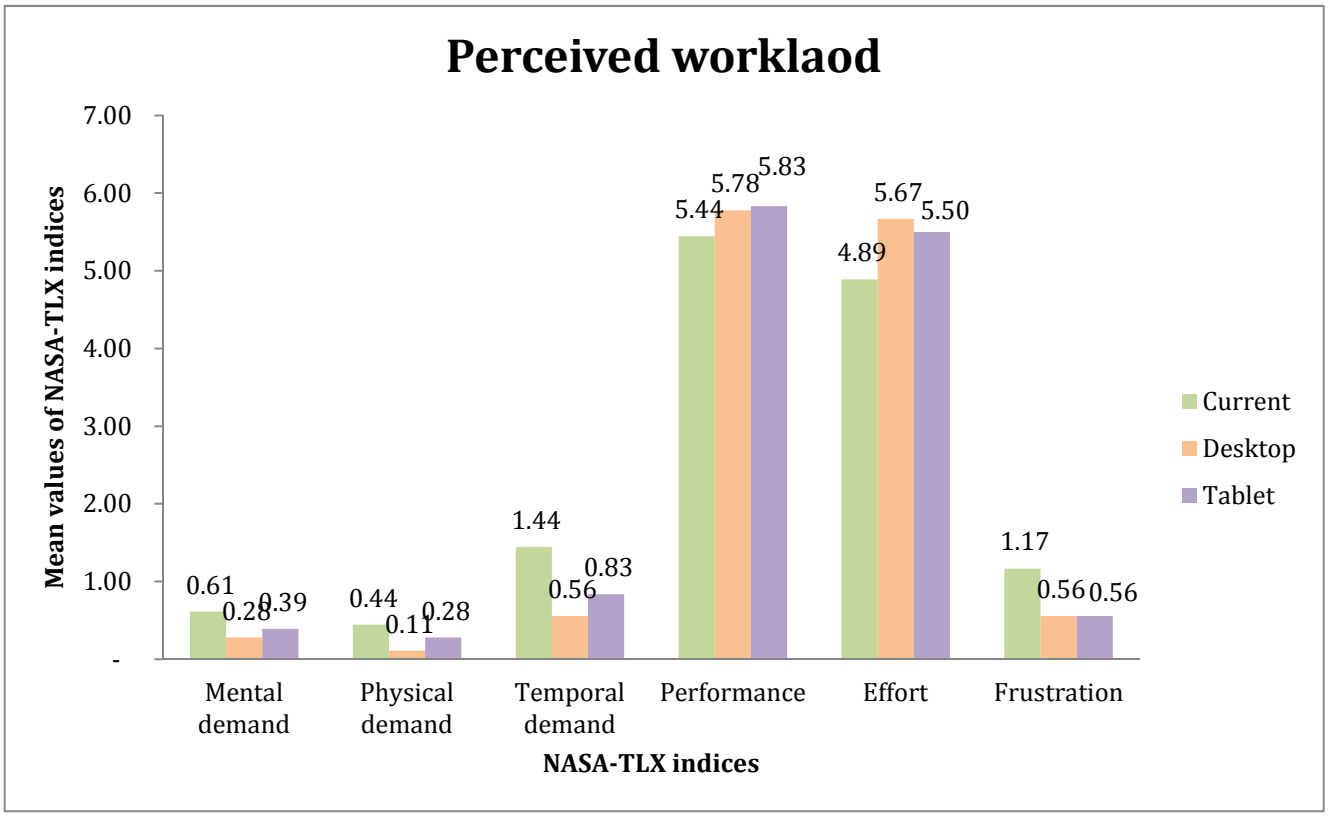


Figure 6.7 Mean scores of NASA-TLX workload indices

Preference questionnaire

The scores on the 7 items of the sign-out process preference questionnaire were used to calculate the overall user satisfaction with the three platforms. It was administered after each participant completed each session of the sign-out process. The scores on all of the items including communication effectiveness, situation awareness, error detection, maintaining records, understanding the benefits, enabling information to be viewed at once, and accessibility from every location were then averaged for each participant for each process to calculate the overall preference questionnaire scores. The results indicated that the satisfaction scores were not normally distributed. As a result, Friedman's and Wilcoxon's tests were used to analyze each item in the sign-out process questionnaire.

The Friedman's test was applied to check for significant differences among the three platforms. The results showed that there were statistically significant differences for 6 of the 7 indices: situation awareness, χ^2 (2, N =18) = 6.889, p = .032, error detection, χ^2 (2, N =18) = 6.242, p = .044, maintaining records, χ^2 (2, N =18) = 6.889, p = .032, understanding the benefit, χ^2 (2, N =18) = 6.889, p = .032, enabling information to be viewed all at once, χ^2 (2, N =18) = 6.889, p = .032, and accessibility from every location χ^2 (2, N =18) = 6.889, p = .032, as shown in Table 6.16. The differences for communication effectiveness were not significant.

Table 6.16

Friedman's test statistics for preference questionnaire

Communication effectiveness	N	18
	Chi-Square	4.270
	df	2
	Asymp. Sig.	.118
Situation awareness	N	18
	Chi-Square	7.476
	df	2
	Asymp. Sig.	.024
Error detection	N	18
	Chi-Square	6.703
	df	2
	Asymp. Sig.	.035
Maintaining records	N	18
	Chi-Square	9.000
	df	2
	Asymp. Sig.	.011
Understanding the benefit	N	18
	Chi-Square	6.261
	df	2
	Asymp. Sig.	.044
Enabling information to be viewed all at once	N	18
	Chi-Square	19.472
	df	2
	Asymp. Sig.	.000
Accessibility from every location	N	18
	Chi-Square	9.000
	df	2
	Asymp. Sig.	.011

The subsequent Wilcoxon's signed-rank test revealed that user satisfaction with the sign-out process ensuring situation awareness on the current sign-out process on the desktop was significantly lower (*Mdn* = 4) than for the sign-out process using the WebApp on the desktop (*Mdn* = 5), Z = -2.565, *p* = .010, but there were no significant differences between the current system and the WebApp on the tablet or between the two WebApp platforms.

For error detection, the results showed that satisfaction with the current sign-out process on the desktop was significantly lower (*Mdn* = 4) than for the sign-out process using the WebApp on the desktop (*Mdn* = 5), Z = -2.153, *p* = .035. However, there were no significant differences between the current system and the WebApp on the tablet or between the WebApp on the tablet and on the desktop.

For maintaining records, the results revealed that satisfaction with the current sign-out process was significantly lower (*Mdn* = 5) than for the sign-out process using the WebApp on the desktop (*Mdn* = 5), Z = -2.573, *p* = .010 and the sign-out process using WebApp on the tablet (*Mdn* = 5), Z = -2.355, *p* = .019. There was no significant difference between the sign-out process using the WebApp on the tablet and on the desktop.

For understanding the benefit, the results revealed that user satisfaction with the current sign-out process on the desktop was significantly lower (*Mdn* = 3.50) than for the sign-out process using the WebApp on the desktop (*Mdn* = 4), Z = -2.581, *p* = .01, but

there was no significant differences between the current system and the WebApp on the tablet or between the two WebApp platforms.

For enabling information to be viewed all at once, the results revealed that satisfaction with the current sign-out process on the desktop was significantly lower (*Mdn* = 3) than for the sign-out process using the WebApp on the desktop (*Mdn* = 5), Z = -3.225, p = .001. The results also indicated that satisfaction with the WebApp on the desktop was higher than for the tablet (*Mdn* = 2), Z = -3.252, p = .001. There was no significant difference between the tablet and the current process.

For accessibility from every location, the results revealed that satisfaction with the current sign-out process on the desktop was significantly lower (*Mdn* = 3) than for the sign-out process using the WebApp on the desktop (*Mdn* = 5), Z = -2.790, p = .005, and for the WebApp on the tablet (*Mdn* = 4), Z = -2.169, p = .030. There was no difference between the WebApp on the desktop and on the tablet.

The descriptive statistics are provided in Table 6.17 and the results for the pair-wise comparisons using a Wilcoxon's signed-rank test are shown in Table 6.18. The mean values for the preference questionnaire scores are displayed in the bar graph in Figure 6.8.

Table 6.17
Descriptive statistics for preference questionnaire

		N	Mean	Std. Deviation	Minimum	Maximum	Percentiles		
							25th	50th (Median)	75th
Communication effectiveness	Current_Communication effectiveness	18	4.22	.808	3	5	3.75	4.00	5.00
	Desktop_Communication effectiveness	18	4.67	.485	4	5	4.00	5.00	5.00
	Tablet_Communication effectiveness	18	4.39	.502	4	5	4.00	4.00	5.00
Situation awareness	Current_situation awareness	18	3.83	1.043	2	5	3.00	4.00	5.00
	Desktop_situation awareness	18	4.56	.616	3	5	4.00	5.00	5.00
	Tablet_situation awareness	18	4.28	.669	3	5	4.00	4.00	5.00
Error detection	Current_error detection	18	3.89	.832	3	5	3.00	4.00	5.00
	Desktop_error detection	18	4.44	.784	3	5	4.00	5.00	5.00
	Tablet_error detection	18	4.11	.900	2	5	3.75	4.00	5.00
Maintaining records	Current_maintaining records	18	3.33	1.534	1	5	1.75	4.00	5.00
	Desktop_ maintaining records	18	4.56	.616	3	5	4.00	5.00	5.00
	Tablet_ maintaining records	18	4.33	.686	3	5	4.00	4.00	5.00
Understanding the benefit	Current_understand the benefit	18	3.50	.985	2	5	3.00	3.50	4.00
	Desktop_understand the benefit	18	4.28	.669	3	5	4.00	4.00	5.00
	Tablet_understand the benefit	18	3.89	.758	3	5	3.00	4.00	4.25
Enabling information to be viewed all at once	Current_Viewed all at once	18	3.17	1.295	1	5	2.00	3.00	4.25
	Desktop_Viewed all at once	18	4.83	.383	4	5	5.00	5.00	5.00
	Tablet_Viewed all at once	18	3.39	1.145	2	5	2.00	3.00	4.25
Accessibility from every location	Current_Every location	18	3.28	1.364	1	5	2.00	3.00	5.00
	Desktop_Every location	18	4.56	.705	3	5	4.00	5.00	5.00
	Tablet_Every location	18	4.06	1.056	1	5	4.00	4.00	5.00

Table 6.18

Pairwise comparisons from Wilcoxon's signed-rank test for preference questionnaire

		Desktop - Current	Tablet - Current	Tablet - Desktop
Situation awareness	Z	-2.565	-1.467	-1.508
	Asymp. Sig. (2-tailed)	.010	.142	.132
Error detection	Z	-2.153	-1.027	-1.540
	Asymp. Sig. (2-tailed)	.031	.305	.124
Maintaining records	Z	-2.573	-2.355	-1.027
	Asymp. Sig. (2-tailed)	.010	.019	.305
Understanding the benefit	Z	-2.581	-1.259	-1.732
	Asymp. Sig. (2-tailed)	.010	.208	.083
Enabling information to be viewed all at once	Z	-3.225	-.483	-3.252
	Asymp. Sig. (2-tailed)	.001	.629	.001
Accessibility from every location	Z	-2.790	-2.169	-1.589
	Asymp. Sig. (2-tailed)	.005	.030	.112

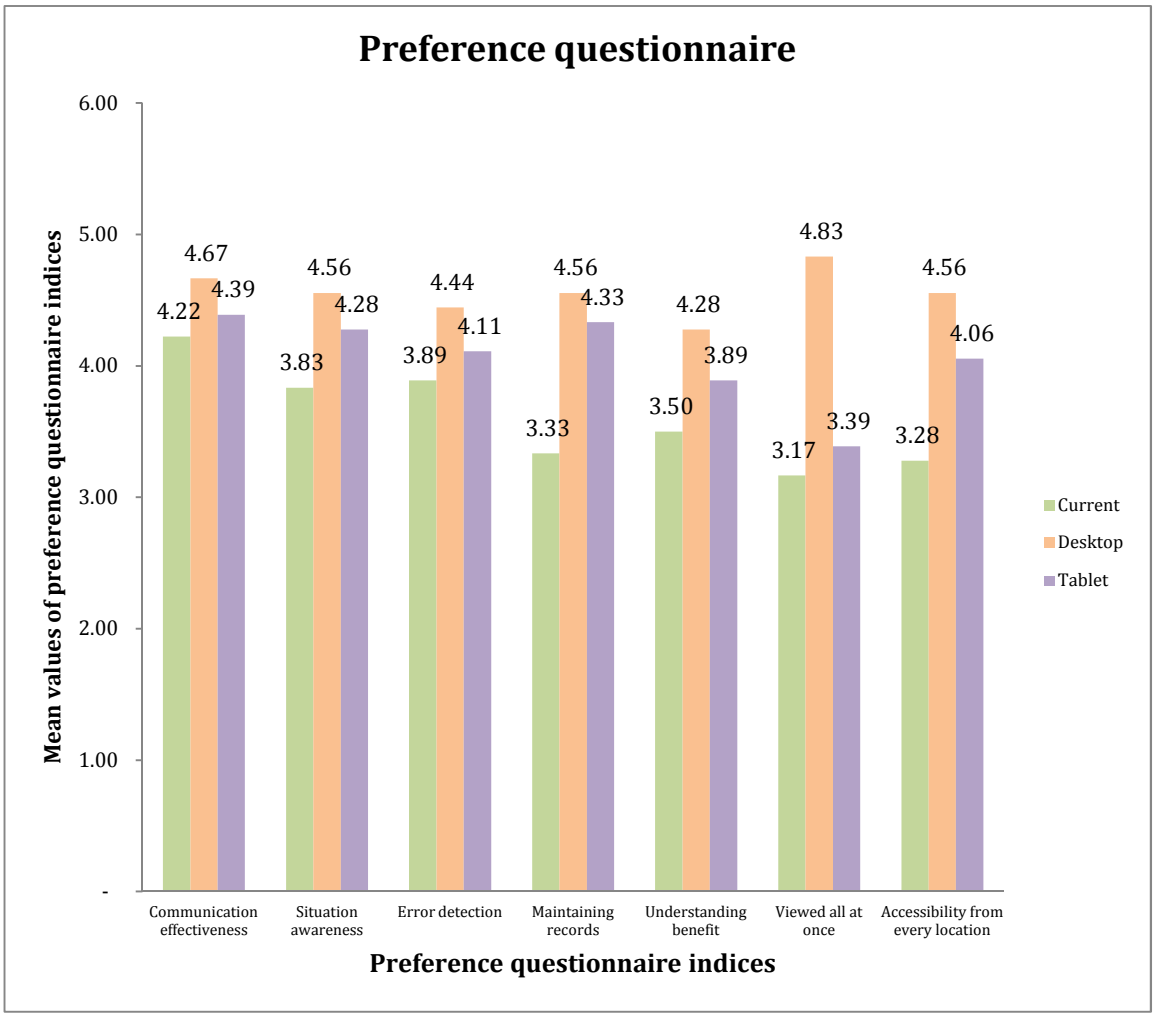


Figure 6.8 Mean scores of preference questionnaire

Preference ranking

The preference for the three sign-out process platforms was measured using the questionnaire seen in Appendix G. The data were not normally distributed; thus, a Wilcoxon's signed-rank test was applied, indicating they were statistically significant. The sign-out process using the WebApp on the desktop was preferred over the current sign-out process on the desktop (Z = -2.786, p = .0005) and the sign-out process using the WebApp on the tablet (Z = -3.041, p = .002). Fourteen of the eighteen participants preferred the sign-out process using the WebApp on the desktop. Two preferred the current system and two preferred the tablet. The results of Wilcoxon's signed-rank test are given in Table 6.19, with a plot of the median values of preference ranking shown in Figure 6.9.

Table 6.19

Pairwise comparisons from Wilcoxon's signed-rank test for preference ranking

	Desktop_Ranking - Current_Ranking	Tablet_Ranking - Current_Ranking	Tablet_Ranking - Desktop_Ranking
Z	-2.906	-.164	-3.041
Asymp. Sig. (2-tailed)	.004	.870	.002

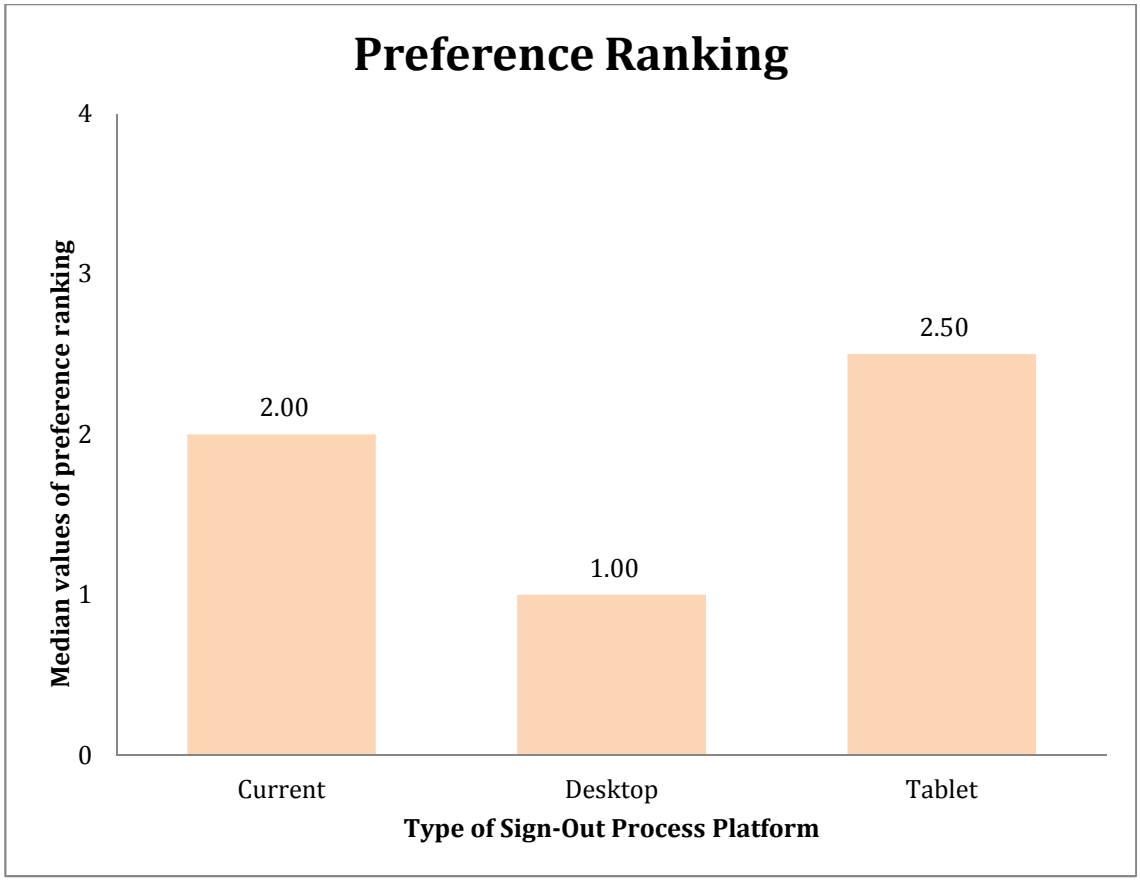


Figure 6.9 Median values of preference ranking

CHAPTER VII

DISCUSSION

The goal of this research was to redesign the sign-out section of the surgical safety checklist using a user-centered design methodology to make it more efficient and more compatible with the workflow of the surgical team. The results from this study supported four of the seven proposed hypotheses, specifically those addressing the number of errors made while completing the sign-out process, the time taken to initiate and complete the sign-out process, the NASA-TLX workload scores comparing the current system and the web-based app platforms, and the preference questionnaire scores. The two hypotheses based on the SUS scores and the hypothesis regarding workload scores for the WebApp on the desktop versus the WebApp on the tablet were not supported due to a lack of statistically significant differences. These results and their implications are discussed in this chapter. The results of semi-structured interviews conducted at the end of the study are also discussed where they help to explain the results reported in Chapter VI.

Time Taken To Initiate and Complete the Sign-Out Process

As hypothesized, the time taken to initiate and complete the sign-out process was shorter for the current system. Specifically, for time taken to initiate, the sign-out process took 43% less time using the current sign-out process on the desktop (*Mean*=2.00s) than the WebApp on the a desktop (*Mean*=3.50s) and 32% less than the WebApp on the tablet (*Mean*=2.94s). For time taken to complete, the current sign-out

process on the desktop was 55% faster (*Mean*=37.33s) than the WebApp on the desktop (*Mean*=83.72s), and 39% faster than the WebApp on the tablet (*Mean*=61.56s). In addition, the time to complete the sign-out process using the WebApp on the tablet was 26% faster than for the WebApp on the desktop.

One explanation for these results involves the time needed to support the technology required for the two WebApp platforms. Because the current system does not depend on an internet connection, it takes the least amount of time to initiate and complete. The responses from the semi-structured interviews conducted at the end of the study support this conclusion. As seen in Table 7.1, item 5, six of the eighteen participants revealed that the tablet took more time to initiate and complete because of the internet connection requirement.

Time was also probably affected by the learning effect. Using the two WebApp platforms required learning a new technology and process, one that involved clicking on several sign-out items.

Performance Measures—Errors

Performance measures are discussed here in terms of three types of error: number of sign-out steps performed incorrectly, number of sign-out items skipped, and number of sign-out items not discussed. The results for the number of sign-out steps performed incorrectly indicated no significant differences among the three sign-out process platforms.

The number of checklist items skipped is one of the most critical issues in completing the checklist (Fourcade et al., 2012). The number of skipped sign-out items was significantly higher for the current system, with no items being skipped for the sign-out process using either the WebApp on the desktop or on the tablet. These findings are consistent with the expectations of this study. One of the features of the WebApp was that every item had to be checked off before the sign-out process was submitted. The results of the semi-structured interviews showed that at least six participants using the WebApp on the desktop and at least five using a WebApp on the tablet felt the App either prevented them from skipping items (See Table 7.1, item 9) or reduced the number of skipped items (see Table 7.1, item 10).

Failure to discuss an issue is the most frequent cause of adverse events in all aspects of health care, resulting in problems that range from delays in treatment to medication errors to wrong-site surgery (Sutcliffe, Lewton, & Rosenthal, 2004). The number of sign-out items not discussed was significantly higher for the current system than for the WebApp on the desktop. This appears to have been due to the improved sign-out process checklist in the WebApp paired with the projection of the checklist on the wall in the WebApp on the desktop condition. This conclusion is supported by response items 11 and 12 shown in Table 7.1.

Subjective Measures

The subjective measures include the System Usability Scale scores, the NASA-TLX perceived workload, preference questionnaire scores, and a preference ranking.

The SUS, which consists of the ten items seen in Appendix E, indicated no significant difference among the three sign-out process platforms in terms of perceived usability. Although there was no significant in the SUS scores for the WebApp on the desktop and on the tablet, nine of the eighteen participants indicated that the WebApp on the tablet was cumbersome, while only one participant mentioned this for the WebApp on the desktop (see item 19, Table 7.1). Six participants indicted that the WebApp on the tablet integrated well with the existing workflow while ten participants indicated that the WebApp on the desktop did (see item 17, Table 7.1). The reason for these responses could be that, at the end of the surgery, the participants had to help other surgical team members complete the surgical procedure while completing the sign-out process. Thirteen participants noted that the WebApp on the desktop supported the existing work environment, while no one noted this for the WebApp on the tablet (see item 29, Table 7.1).

According to Bangor, Kortum, and Miller (2008), "products which are at least passable have SUS scores above 70, with better products scoring in the high 70s to upper 80s. Truly superior products score better than 90. Products with scores of less than 70 should be considered candidates for increased scrutiny and continued improvement and should be judged to be marginal at best." Hence, the usability of the current sign-out process (*Mean*=76.53) can be rated as "passable" while the usability of the sign-out process on the desktop (*Mean*=85.97) and on the tablet (*Mean*=82.92) can be rated as "better."

Only two metrics of the six in the NASA-TLX workload instrument, temporal demand and frustration, were found to have significant differences across platforms. Temporal demand was perceived to be higher for the current system than for the WebApp on the tablet. The data from the interviews, shown in Table 7.1, item 24, indicated that seven participants felt rushed while completing the current sign-out process at the end of the surgery but only two participants using the WebApp on the desktop and four participants using the tablet did. The unstructured organization of the information in the instructions and of the checklist items in the current system may have resulted in the higher temporal demand.

Workload scores tended to be low for all three platforms on four workload indices, including mental demand, physical demand, temporal demand, and frustration, but high for two workload indices, performance and effort. Perhaps this is because participants felt that while the sign-out process was easy to complete, it was a process they typically did not perform outside of this research study.

Frustration was perceived to be significantly higher for the current system than for the WebApp on the desktop, perhaps because the design of the current system provides no indication of where the user is in the process and provides unclear instructions about how to complete the sign-out process. This explanation is supported by Scriven's observation that a checklist is typically a list of action items or criteria arranged in a systematic manner, allowing the user to record the presence or absence of the individual items, thus ensuring all are considered or completed (Scriven, 2000).

Without the ability to record the presence or absence of the individual items in the current system, the participants lose focus, and this affects their ability to complete the sign-out process efficiently.

The results of the preference questionnaire found significant differences in satisfaction with situation awareness, error detection, maintaining records, understanding the benefits, enabling information to be viewed at once, and accessibility from every location, with the only exception being the satisfaction with communication effectiveness. The mean scores for situation awareness and error detection were higher for the sign-out process using the WebApp on the desktop than for the current system, perhaps because of the intuitive organization of the sign-out items in the WebApp. In addition, the current system does not help users to keep track of completed items, especially when interrupted.

For maintaining records, there were significant differences between the current system and the WebApp on the desktop and between the current system and the WebApp on the tablet. Participants using the web application on the desktop and the tablet with a database management system could record the execution of the sign-out process by clicking on “submit” button. The current system provides no built-in recording capability.

Since past research found that a lack of understanding the benefits of completing the checklist is one of the barriers that prevent users from using it (Fourcade, Blache, Grenier, Bourgain, & Minvielle, 2012), efforts were made in the redesign of the sign-out

process to ensure that users understood its utility (helping to detect situations overlooked in the OR). The satisfaction with understanding the benefits of the sign-out process was found to be significantly lower for the current system than for the WebApp on the desktop. As shown in Table 7.1, item 32, twelve of the eighteen participants indicated that the WebApp on the desktop provided them with an understanding of necessity of completing the sign-out process at the end of surgery, while only four of the eighteen participants indicated this was so for the current system.

The ability to view relevant information all at once was one of the most critical concerns that users addressed in Step 1 of Phase I of this research. The results of the preference questionnaire found that satisfaction with respect to this was significantly lower for the current system than for the WebApp on the desktop. The results of the semi-structured interviews, shown at item 33 in Table 7.1, showed fifteen of the eighteen participants indicated that the WebApp on the desktop displayed relevant information at once but only three indicating that the current system did. Moreover, as noted in item 34, twelve of the eighteen participants indicated that the current system displayed unnecessary information, perhaps because it displayed two additional sections of the checklist not relevant during the sign-out process performed at the end of surgery.

Another concern that was discovered early in this study was that the sign-out document should be accessible from every location. The mean scores for the accessibility of the sign-out process using the WebApp on the desktop and the tablet were higher than those for the current system. The information presented by the

WebApp on the desktop, like the information presented on the current system, was also projected on the wall of the OR. While the information presented by the WebApp on the tablet was not projected, this device was easily transported in the OR. Five of the eighteen participants indicated that the current sign-out process was complex in terms of information organization (see item 22, Table 7.1), while none indicated this for the WebApp on the desktop or the tablet.

When participants were asked to rank the three sign-out process platforms, fourteen participants, or 77.78%, preferred the sign-out process using the WebApp on the desktop. This result is supported by high scores for the WebApp on the desktop in terms of usability and satisfaction, and low scores in terms of workload. Moreover, the results indicated that the WebApp on the desktop minimizes the number of incorrect sign-out steps and sign-out items skipped, while it enhances discussion of the steps among surgical staff. Results from the semi-structured interviews seen in Table 7.1, items 17 and 36, show that ten of the eighteen participants felt that this platform supports the existing workflow and fourteen felt that it was compatible with the electronic devices currently available in the hospital.

Two participants preferred the tablet while two preferred the current system. The number of people preferring the WebApp on the tablet was much lower than for the WebApp on the desktop, perhaps because of the tablet's incompatibility with the existing workflow, since it requires the use of both hands; as a result, it complicated the process of assisting the completion of surgical procedure. While tablets are not currently

used within the organization, when asked, almost all participants indicated that they would use the WebApp on the tablet if it could be mounted on the wall and removed when it was convenient to use as a handheld device. Participants also responded that the hospital has not indicated that mobile devices would be implemented in the hospital anytime soon.

Table 7.1

Participant responses from semi-structured interviews

Responses	Number of responses/Platform		
Time to initiate and complete	Current	Desktop	Tablet
1. The sign-out process is quick to initiate.	6	0	0
2. The sign-out process is quick to complete.	6	0	0
3. The sign-out process requires more steps to complete.	0	5	4
4. The sign-out process requires more time to initiate since it is displayed on a projector	2	4	0
5. The sign-out process takes more time to initiate and complete with internet connection requirement.	0	5	6
Sign-out items performed incorrectly	Current	Desktop	Tablet
6. The sign-out process enables incorrect steps to be detected easily.	1	6	1
7. The sign-out process enables users to perform the sign-out steps incorrectly	8	0	1
8. The sign-out process reduces incorrect steps made in the OR.	3	6	0
Sign-out items skipped	Current	Desktop	Tablet
9. The sign-out process prevents users from skipping items.	0	5	3
10. The sign-out process reduces number of items that are skipped.	0	6	5
Sign-out items not discussed	Current	Desktop	Tablet
11. The sign-out process encourages discussion among surgical staff.	3	8	5
12. The sign-out process encourages other team members to discuss their concerns when it is displayed on the wall.	1	7	0
Usability responses	Current	Desktop	Tablet
13. The sign-out process encourages users to use it frequently.	4	9	2
14. The sign-out process is complex	7	3	3
15. The sign-out process is easy to use.	5	6	6
16. The sign-out process produces need of technical support to users.	1	0	0
17. The sign-out process integrates well with existing workflow.	7	10	6
18. The sign-out process contains inconsistent information organization.	3	0	0
19. The sign-out process is cumbersome to use.	5	1	9
20. The sign-out process promotes users' confidence	4	9	6

21. The sign-out process takes a lot of time to learn how to use.	1	0	3
Workload responses	Current	Desktop	Tablet
22. The sign-out process is complex in terms of information organization.	5	0	0
23. The sign-out process requires users to pay extra attention for each sign-out item.	3	0	1
24. The sign-out process produces pressure to users to rush through it at the end of the surgery.	7	2	4
25. The sign-out process contains a lot of information that increases user frustration.	6	7	10
26. The sign-out process is difficult to accomplish without the ability for users to recall where they left off before an interruption.	8	0	0
27. The sign-out process displays unstructured information that loses user's attention to complete the sign-out process.	8	2	6
Preference questionnaire responses	Current	Desktop	Tablet
28. The sign-out process encourages discussion among surgical staff while closing the procedure.	4	9	5
29. The sign-out process supports existing work environment.	6	13	0
30. The sign-out process helps to detect error in the OR.	1	9	3
31. The sign-out process maintains a record.	0	12	10
32. The sign-out process encourages users to understand the necessity to complete the sign-out process.	4	12	9
33. The sign-out process displays relevant information all at once.	3	15	12
34. The sign-out process displays unnecessary information.	12	2	2
35. The sign-out process is accessible from every location.	10	7	7
36. The sign-out process supports the current electronic devices provided in the hospital.	7	14	0

CHAPTER VIII

CONCLUSION

An analysis of the study results and the final comments of the participants indicate that the participants benefit most by using the web-based sign-out process on the desktop. However, if one day the hospital decides to implement mobile devices, many of the participants would be open to performing the process on a tablet. Some participants noted that one advantage of the current system was that it did not depend on a connection to the internet. Thus, it might be useful to have a Word or PowerPoint based version of the redesigned checklist available on the desktop computer as well.

Participants also suggested that the sign-in and time-out processes should be redesigned and implemented as web-based checklists, like the sign-out process. Once all three phases are available as web-based checklists, implementing them into the surgical staff desktop computer would be the next step in enhancing the routine use of the surgical safety checklist.

The next step toward implementing the WebApp sign-out process is currently being reviewed by the administrators at Greenville Memorial Hospital, including the Clinical OR Director and Medical Director of Perioperative Services and Chairman of the Department of Anesthesiology. If approved, the WebApp will be implemented on desktop computers in the OR.

This research, however, is only a first step. Future studies could include the following:

- The current study evaluated the performance of a web-based application on the tablet without displaying the sign-out process on a projector because of the limited interconnection capabilities of the projectors at Greenville Memorial Hospital. A future study could investigate conducting the sign-out process using the WebApp on a tablet while also projecting the checklist.
- The current study only collected subjective data from the nurses because of incompatibilities in the schedules of the other surgical staff in the OR. It is recommended that further research be conducted that include subjective data from the surgeons, surgical technicians, CRNAs and anesthesiologist.
- To control for effects caused by participant familiarity with the current sign-out process, a follow-up study with participants unfamiliar with it is recommended.

APPENDICES

APPENDIX A

INFORMED CONSENT TO PARTICIPATE IN INTERVIEWS AND OBSERVATIONS

IRB File # Pro00023648

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Human Factors Analysis of Surgical Safety Checklist Usage: Needs Analysis to Optimize The Presentation of Surgical Safety Checklist Information.

Study to be Conducted at: Greenville Hospital System
701 Grove Road Greenville, South Carolina 29605

Principal Investigator: Richard Wilson, CRNA, MNA (864) 455-6080

INTRODUCTION

You are being asked to participate in a research study. The Institutional Review Board of the Greenville Hospital System has reviewed this study for the protection of the rights of human participants in research studies, in accordance with federal and state regulations. However, before you choose to be a research participant, it is important that you read the following information and ask as many questions as necessary to be sure that you understand what your participation will involve. Your signature on this consent form will acknowledge that you received all of the following information and explanations verbally and have been given an opportunity to discuss your questions and concerns with the principal investigator or a co-investigator.

A description of this clinical trial will be available on *http://www.ClinicalTrials.gov*, as required by U.S. Law. This Web site will not include information that can identify you. At most, the Web site will include a summary of the results. You can search this Web site at any time.

PURPOSE

The specific purpose of this initial study is to observe the way surgical teams use surgical safety checklists and interview surgical staff at GHS to better understand their needs, goals, and concerns with the checklist procedure. Needs analysis, a human factors tool, will be used to analyze the initial observation and interview data. Collected data will be used to generalize the knowledge and plan for later stages of research. The investigator is conducting this study as part of the thesis requirements of Clemson University. We are interviewing about 15 surgical staff at Greenville Health System. If you agree to participate in this research, the interview process will take about 30 minutes. You will be asked to answer questions and provide feedback on a general concerns about surgical safety checklists. The researchers will ask you questions about your typical uses of the checklists, why you use them, motivation and expectation of using the checklists, how you normally use checklists, likes and dislikes about checklists, and suggestions for improvement. We will not plan to ask any questions that are personal in nature. The interview is not a test or anything like that; it is just to find

out about your needs and opinions on surgical safety checklist. You do not have to answer any questions that you do not wish to answer.

PROCEDURES

If you sign this form, you are saying that you wish to take part in an interview.

If you agree to participate in this study, we will ask you to do the following things:

- After you sign this form, you will take part in an interview where you will be asked to answer questions and provide feedback on general concerns you have about the checklists.
- You will also be asked to complete short demographic information about your working position in GHS and your role on the surgical team.

The interview should last no longer than **30 minutes**. The interview session will be hand-written so that the research team can learn about what you said.

POSSIBLE RISKS

There are no known physical risks associated with interviewing surgical staff. There is a possible risk of loss of confidentiality.

POSSIBLE BENEFITS

There are no direct benefits to you by participating in this study. The research is focused on exploring the use of surgical safety checklists performed by surgical teams to eliminate critical barriers that prevent surgical staff from using the checklists.

COST TO YOU FOR PARTICIPATING IN THIS STUDY

There will be no cost to you for participating this study.

PAYMENT FOR PARTICIPATION

To You: You will not be paid to participate in this study

To Investigators:

Neither the investigators nor professional staff will receive any special compensation above and beyond their regular salaries for time and effort to perform procedures, tasks, and accurately collect and submit data.

COMPENSATION FOR INJURY AS A RESULT OF STUDY PARTICIPATION

If you get hurt or sick because of your participation in this study, emergency medical treatment is available but will be provided at the usual charge..

No financial compensation (payment) will be available to you from the Greenville Hospital System or the investigators as part of this study. You or your insurance company will be charged for continuing medical care and/or hospitalization. You understand that you have not given up any of your legal rights by signing this consent form.

VOLUNTARY PARTICIPATION
Participation in this study is completely voluntary (your choice). You may refuse to participate or withdraw from the study at any time. If you refuse to participate or withdraw from the study, you will not be penalized or lose any benefits. Your decision will not affect your relationship with your doctor or hospital.

NEW INFORMATION
During this study, you will be told of any important new information that may affect your willingness to participate in this study.

CONFIDENTIALITY
Study records with your personal information on them will be kept private as required by law. Except when required by law, you will not be identified by name, social security number, address, telephone number, or any other personal information in study records given outside of Greenville Hospital System (GHS). The contact information we recorded will be destroyed after completion of this research. We will not share your answers with anyone outside this study. This study does not involve any medical tests or procedures; no information will be put in your medical record.

Your study records are considered confidential (private), but absolute confidentiality cannot be guaranteed. Information may be kept on a computer. All records may be examined and copied by the Institutional Review Board of the Greenville Hospital System, and other regulatory agencies. This study may result in presentations and publications, but steps will be taken to make sure you are not identified by name.

CONTACT FOR QUESTIONS
For more information concerning this study and research-related risks or injuries, or to give comments or express concerns or complaints, you may contact the principal investigator, Richard Wilson, CRNA, MNA, *at* (864) 455-6080.

You may also contact a representative of the Institutional Review Board of the Greenville Hospital System for information regarding your rights as a participant involved in a research study or to give comments or express concerns, complaints or offer input. You may obtain the name and number of this person by calling (864) 455-8997.

A survey about your experience with this informed consent process is located at the following website:

http://www.ghs.org/Research-and-Clinical-Trials

Participation in the survey is completely anonymous and voluntary and will not affect your relationship with your doctor or the Greenville Hospital System. If you would like to have a paper copy of this survey, please tell your study doctor.

CONSENT TO PARTICIPATE

Study investigators have explained the nature and purpose of this study to me. I have been given the time and place to read and review this consent form and I choose to participate in this study. I have been given the opportunity to ask questions about this study and my questions have been answered to my satisfaction. I have been given a copy of my study doctor's Notice of Privacy Practices. I agree that my health information may be used and disclosed (released) as described in this consent form. After I sign this consent form, I understand I will receive a copy of it for my own records. I do not give up any of my legal rights by signing this consent form.

_____

Printed Name of Participant

_____ _____

Signature of Participant Date Time

_____ _____

Signature of Witness Date Time

INVESTIGATOR STATEMENT

I have carefully explained to the participant the nature and purpose of this study. The participant signing this consent form has (1) been given the time and place to read and review this consent form; (2) been given an opportunity to ask questions regarding the nature, risks and benefits of participation in this research study; and (3) appears to understand the nature and purpose of the study and the demands required of participation. The participant has signed this consent form prior to having any study-related procedures performed.

_____ _____

Signature of Investigator Date Time

Principal Investigator: Richard Wilson, CRNA, MNA (864) 455-6080

Co-Investigators:	Dr. Joel Greenstein	(864) 656-5649
	Dr.Gilbert Ritchie	(864) 455-7171
	Sumonthip Chompoodang	(386) 747-1707
	Reshmi Koikkara	(864) 656-7889
	Mahesh Sreedharan	(864) 353-4862

APPENDIX B

INFORMED CONSENT TO PARTICIPATE IN A RESEARCH STUDY (SURVEYS)

CONSENT TO PARTICIPATE IN A RESEARCH STUDY

Human Factors Analysis of Surgical Safety Checklist Usage: Needs Analysis to Optimize The Presentation of Surgical Safety Checklist Information.

You are being asked to participate in a research study because of your knowledge of the surgical safety checklist and its use during the sign-out process. If you agree to take part in this study, you will be asked to complete a survey. The survey asks for your opinions about features that could be included in the design of surgical safety checklist. The purpose of this study is to better understand the relative importance of these different features to you and to other members of the surgical team.

Participation in this study is completely voluntary. You may refuse to participate or withdraw from the study at any time, and you will not be penalized or lose any benefits. Your decision will not affect your relationship with the hospital. We expect that it will take about 15 minutes to complete the survey.

Your answers are confidential and anonymous. There is no identifiable information connected to the survey data you submit. Only aggregate data will be shared. No questions are personal in nature. You do not have to answer any questions that you do not wish to answer. All records may be examined and copied by the Institutional Review Board of the Greenville Health System, and other regulatory agencies.

There are no known risks related to participation in this study. The benefit of participating in this study is that you are contributing to an understanding of how to improve the design of the surgical safety checklist, for use during the sign out procedure.

For more information concerning this study and/or to give comments or express concerns or complaints, you may contact the principal investigator, Richard P. Wilson, (864) 455-6080. You may also contact a representative of the Institutional Review Board of the Greenville Hospital System for information regarding your rights as a participant involved in a research study or to give comments or express concerns, complaints or offer input. You may obtain the name and number of this person by calling (864) 455-8997.

I have read the above information and would like to participate in the survey related to this research project.

Yes

APPENDIX C

SIGN-OUT PROCESS SURVEY

Sign-Out Process Survey

Thank you for agreeing to take this survey. Our research team is evaluating the sign-out system in the surgical safety checklist in an effort to redesign sign-out process.

For each of the following features that could be included in an impressed sign-out process, please indicate on a scale of 1 to 5 how important the feature is to you. Please use the following scale:

1. Feature is undesirable. I would not consider using a sign-out process with this feature.
2. Feature is not important, but I would not mind having it.
3. Feature would be nice to have, but is not necessary.
4. Feature is highly desirable, but I would consider using a sign-out process without it.
5. Feature is critical. I would not consider a sign-out process without this feature.

Also indicate by checking the box to the right if you feel that the feature is unique, exciting, and/or unexpected.

Importance of feature on scale of 1-5		Feature is unique, exciting, or unexpected
	The sign-out process helps users to be aware of their roles in the sign out process	
	The sign-out process organizes information logically.	
	The sign-out process is standardized across all surgical procedures.	
	The sign-out process is concise.	
	The sign-out process is accessible from every location in the OR.	
	The sign-out process is accessible at any time.	
	The sign-out process is immediately available when surgical staff enter the OR.	
	The sign-out process ensures that the sign-out process is completed at the end of every surgery.	
	The sign-out process ensures that the sign-outs are completed before participants leave the OR.	
	The sign-out process ensures that surgical staff complete the sign-out process.	
	The sign-out process supports emergency cases.	
	The sign-out process integrates well with the existing workflow.	
	The sign-out process can be picked up easily where it was stopped due to an interruption.	
	The sign-out process supports effective communication among the surgical	

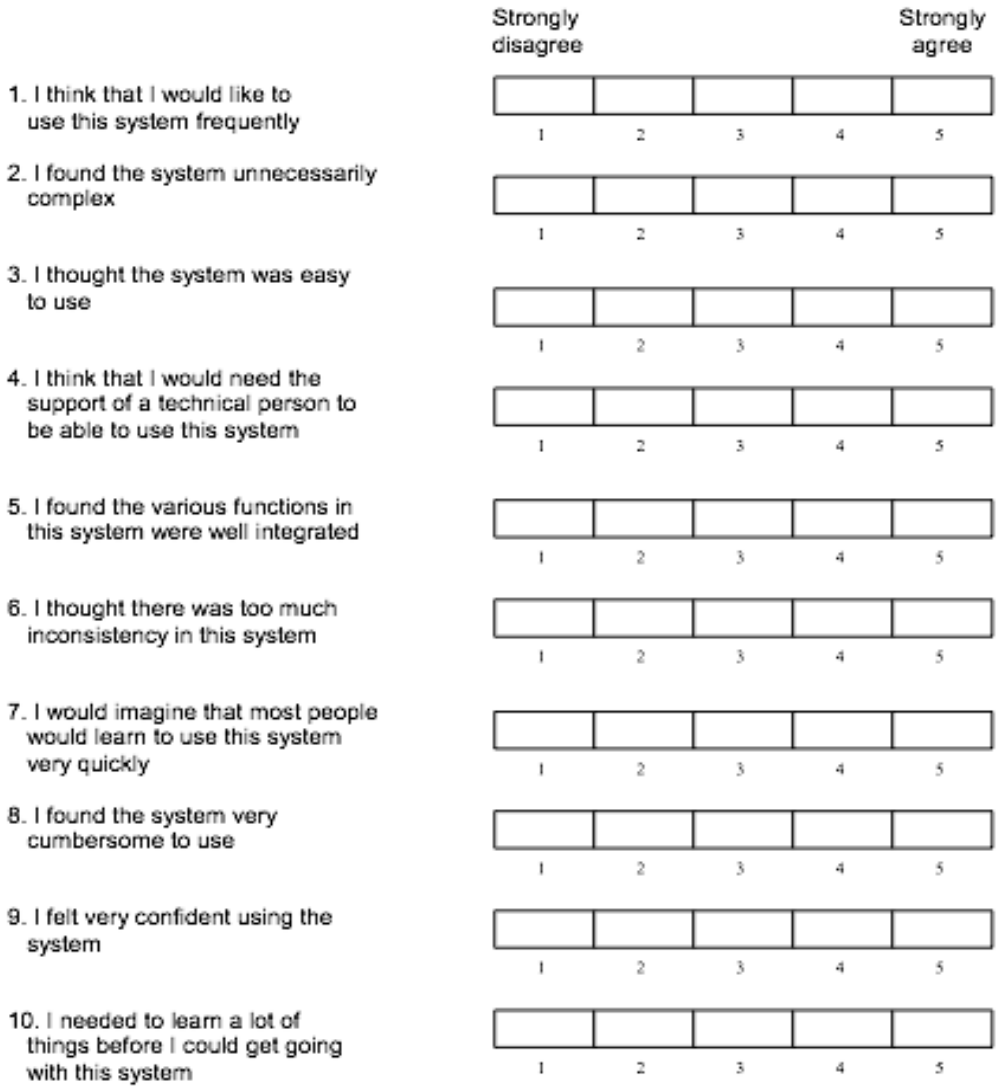
	staff.	
	The sign-out process promotes effective communication.	
	The sign-out process ensures that the sign-out process is discussed by all users.	
	The sign-out process is simple.	
	The sign-out process presents information that is easy to read.	
	The sign-out process is easy to use.	
	The sign-out process helps the participants to remember to complete the sign-out process.	
	The sign-out process ensures that all surgical staff members are aware of their responsibilities for the patient in the OR.	
	The sign-out process promotes understanding of the importance of completing checklist.	
	The sign-out process enables errors to be detected easily.	
	The sign-out process makes it clear when the sign-out procedure is completed.	
	The sign-out process makes surgical staff aware of the sign-out process.	
	The sign-out process ensures that participants understand what information is requires to complete the sign-out process.	
	The sign-out process ensures that users understand the benefits of the sign-out process.	
	The sign-out process helps to reduce the number of errors made in the OR.	
	The sign-out process makes it clear when a step in the sign-out process has been skipped.	
	The sign-out process encourages consistent use.	
	The sign-out process encourages participants to complete the sign-out process.	
	The sign-out process encourages inexperienced users to complete the sign-out process.	
	The sign-out process encourages users to complete the sign-out process before leaving the OR.	
	The sign-out process ensures that participants complete the sign-out process with every patient.	
	The sign-out process encourages vigilance with respect to the sign-out process.	
	The sign-out process is visible.	
	The sign-out process enables all of the relevant information to be viewed at once.	
	The sign-out process maintains a record of the sign-out process.	
	The sign-out process is quick to complete.	

APPENDIX D

SYSTEM USABILITY SCALE QUESTIONNAIRE:*

*Source: Brooke, J. (1996). Usability Evaluation in Industry. Niagara Falls, NY: CRC Press

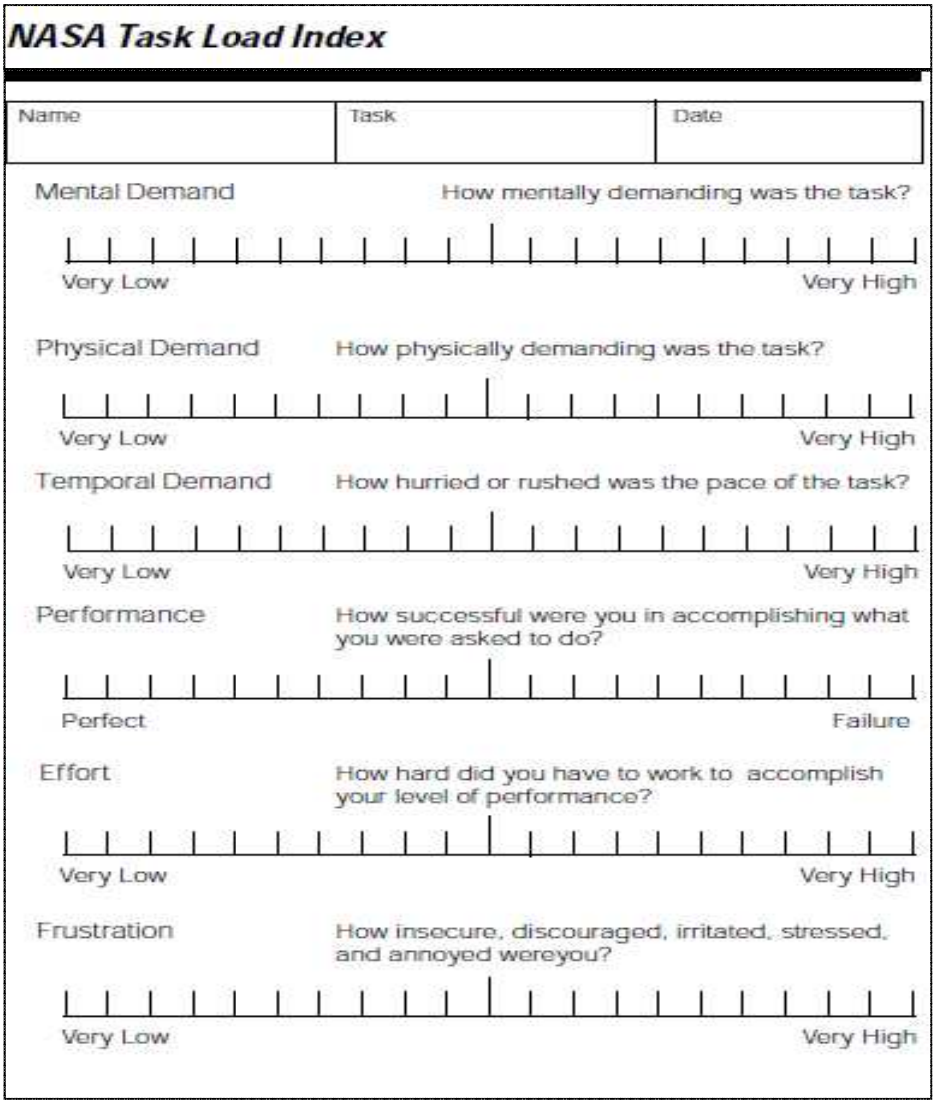
System Usability Scale



APPENDIX E

NASA-TLX SUBJECTIVE QUESTIONNAIRE*

*Source: Hart, S.G., and Staveland, L.E. (1988). Development of NASA-TLX (Task Load Index): Results of Empirical and Theoretical Research. Advances in Psychology, 52, 139-183.



NASA Task Load Index

Name	Task	Date

Mental Demand — How mentally demanding was the task?

Very Low — Very High

Physical Demand — How physically demanding was the task?

Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?

Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?

Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?

Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low — Very High

APPENDIX F

SIGN-OUT PROCESS POST-TEST QUESTIONNAIRE

Sign-out process benchmarking survey

***Your current position at GHS is best described as a(n):**

□ Surgical resident

□ Student Registered Nurse Anesthetist

□ Nursing student

□ Nurse Surgical Technician student

Other (please specify)_____

1) Rate the effectiveness of the communication among surgical staff. (Metric 12)

Not at All		Neutral		Very
1	2	3	4	5

2) On a scale from 1-5, rate the degree to which the sign-out process ensures situation awareness. (Metric 13)

Not at All		Neutral		Very
1	2	3	4	5

3) How satisfied are you with the degree to which the sign-out process helps surgical staff to detect errors? (Metric 19)

Not at All		Neutral		Very
1	2	3	4	5

4) Rate the degree to which the sign-out process maintains a record of sign-out process. (Metric 22)

Not at All		Neutral		Very
1	2	3	4	5

5) Rate the degree to which the sign-out process ensures that users understand the benefits of the sign-out process. (Metric 24)

Not at All		Neutral		Very
1	2	3	4	5

6) On a scale from 1-5, how satisfied are you with the degree to which the sign-out process enables relevant information to be viewed all at once? (Metric 25)

Not at All		Neutral		Very
1	2	3	4	5

7) How satisfied are you with the accessibility of the sign-out process from every location? (Metric 26)

Not at All		Neutral		Very
1	2	3	4	5

APPENDIX G

USER RANKING OF PREFERRED PLATFORM

RANK THE PLATFORMS

Rank the platform that you prefer the most as # 1 and the platform you prefer the least as # 3.

1. Platform 1 –Current sign-out process on a desktop computer

   Rank # _____

2. Platform 2 –Sign out-process using the WebApp on a desktop computer

   Rank # _____

3. Platform 3 –Sign-out process using the WebApp on a tablet

   Rank # _____

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