Improving Usability of Patient Management System in Perioperative Clinic through Heuristic Evaluation

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CERTIFICATE OF APPROVAL

This is to certify that the Master's Capstone Project of

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"*Improving Usability of Patient Management System in Perioperative Clinic through Heuristic Evaluation*"

Has been approved

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Abstract

The demand for quality of care is ever increasing. The perioperative surgical clinic is one of the key components in improving the quality of care through identification, risk stratification, and management of the patients going through elective surgeries. Perioperative surgical clinic is a concept that has existed for a long time that is implemented in various ways. To help its operation, the perioperative surgical clinic utilizes a patient management system. However, the current usability relies on a software engineer's perspective rather than the actual users. This project reports a usability inspection of the current system through heuristic evaluation by actual users. After evaluation, potential remedies were suggested to the vendor for further improvements in the system.

Introduction

Perioperative evaluation is an important process before elective surgery. Adequate perioperative management can improve quality of care by decreasing length of stay, surgery cancellations, and complications. The financial impact of inadequate perioperative management is significant. Estimated cost per surgical complication in a case averages around $10,000.[1] Cancellations on the day of surgery costs are estimated at around $1500 per hour.[2] Fragmented perioperative care with surgical patients are at risk of complications, cancellations, increased length of stay.

A perioperative clinic focuses on patient-centered coordination of care to improve the quality of care. Quality of care can be achieved through the clinic and its process by decreasing unnecessary testing, following the guidelines, and streamlining patient handoffs between the outpatient clinics and the operating rooms.[3] Identification of high-risk patients and their

medical optimization before surgery has been shown to improve patient satisfaction and patient safety.[4] To develop an effective perioperative clinic, an appropriate perioperative patient management process is required. A perioperative management process entails coordination of perioperative clinic, patient education, case management, preop testing, insurance authorization, medication review, and surgical services. A standardized care plan and coordination are necessary to successfully augment a perioperative process.[5]

The utilization of health information technology and data management services are becoming essential to perioperative patient care. Health information technology advances such as electronic health records (EHR) implementation has significantly improved charting and data collection of patient's medical history. Along with electronic health record implementation, CHI Franciscan perioperative surgical clinic has made use of a third-party patient management system. The patient management system encompasses patient scheduling, alerts for the patient and the nurses for phone calls, classes for education, operation dates, and follow-ups. The goal of implementing a patient management system is to ensure standardized care is delivered to all patients going through elective surgery. The alerts and notifications allow users to coordinate the fragmented phone calls and appointments. Although the intention is to improve standardized care and clinical workflow, if it is not properly designed, users experience a sharp learning curve in navigating the system. It can lead to frustration of the users and decrease the efficiency of the process. When there are concerns for usability in a software or a website, a formal evaluation helps improve user experience. Research shows, health informatics systems are most effective when they are centered on the users.[6] We explored the application of heuristic evaluation of implemented patient management system by experts who are the system users in this project.

METHODS

Heuristic evaluation

Heuristic evaluation is done through expert examination of the user interface based on principles such as Nielsen's ten usability heuristics.[7] It is an important tool that can effectively identify usability problems within a technology.[8] Problems in areas of confusion, complex designs and steps, navigation issues can be identified without expensive laboratories, large personnel, and testers. An expert heuristic evaluation can recognize many usability problems. Increased numbers of evaluators can improve the findings of usability problems.[9] In some studies, heuristic evaluation can identify issues that are missed by typical usability testing.[10] Heuristic evaluation can be used before system implementation to identify problems. It can also be used to evaluate the effectiveness of the system afterward and reflect the necessary changes.

The project used a variation of Nielsen's ten usability heuristics as a principle of evaluation. The Xerox checklist for heuristics is developed using Nielsen's heuristics principle while addressing specific questions about technology systems.[11] The original Xerox checklist has thirteen sections from ten principles of Nielsen's heuristics and three additional principles. However, this project did not use the three additional principles to reduce confusion in the evaluation. Principles included are visibility of system status, match between system and the real world, user control and freedom, consistency and standards, help users recognize and recover from errors, error prevention, recognition rather than recall, flexibility and efficiency of use, Aesthetic and minimalist design, help and documentation. [Table 1.] [10-11]

Principles	Definition
Visibility of System status	Users should be informed about what is going on
Match between system and real world	System use words, phrases, and concepts familiar to the user
User control and freedom	Users should be able to undo, redo, cancel any actions
Consistency and standards	The system should follow platform and industry conventions in regards to words, situations, or actions.
Help users recognize, diagnose, and recover from errors, Error prevention	Error messages should be easily recognizable (no error codes), accurately identify the issue, and suggest a solution
Error prevention	The ideal system design is to prevent errors from occurring in the first place.
Recognition rather than recall	The user should not rely on memory to process information. Information should be visible and easily accessible without memory.
Flexibility and efficiency of use	Providing shortcuts, customization can improve usability
Aesthetic and minimalistic design	Interface should be relevant to the information contained. Simple and visible.
Help and documentation	Help and documentation, step by step instructions help user to complete tasks.

Table 1. Heuristics principles [11]

Evaluators

Experts in usability and design usually perform heuristic evaluation. However, non-experts can also use the same principles to follow the evaluation to find usability issues. Three experts conducted the heuristic evaluation in this project. Two of the experts were multi-domain experts in usability, health informatics, and healthcare. One had expertise in electronic health records, patient management in the clinical setting. The primary evaluator is the author of this project who is a physician participating in perioperative clinic who has worked with EHR implementation and a student of clinical informatics at graduate level studies. Second expert is the director of perioperative clinic who has participated in EHR implementations and has served in clinical informatics advisory board for many years providing heuristic evaluation and

feedback in usability of health information technology. Third expert is a registered nurse who a non-expert in heuristics and health informatics but is an expert in user interface and utilization of EHR, patient management software in the clinical settings. As the system was already operating in the current setting, the evaluation was done after implementation. A standardized form of heuristics evaluation was achieved among the evaluators using the Xerox checklist.

Procedure

The team initially met to review the ten heuristics principles by Nielsen to share the understanding of the principles. Then, the evaluators were given a spreadsheet of Xerox checklist to be completed. The experts independently conducted the evaluation twice. Once the experts completed the checklists, the results were aggregated and discussed to form a general consensus on each principle's violations and the issues. After the results were aggregated and a consensus was reached in each principle, system developers were notified of the evaluations for a potential improvement in the system. The consensus was based on the frequency of the problem, potential impact, and its persistence.[7]

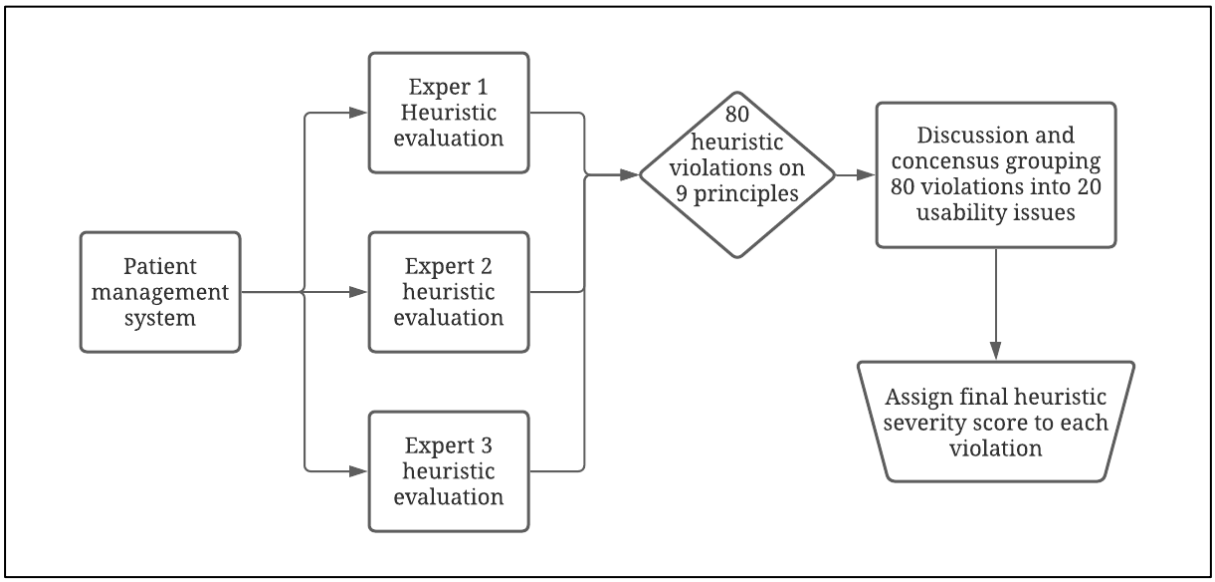

Figure 1. Methods flow diagram

Xerox checklist

The Xerox checklist rating has three parts in each question. The first column checks pass or fail in the question of the checklist. The second column has a 5-level rating scale in regards to the severity of the usability problem: 0= No problems; 1 = cosmetic problems; 2 = minor usability problems; 3 = major usability problems; 4 = Catastrophic problems. The third column of the evaluation gives space for elaborating the issues evaluators identified. The checklist consists of up to 50 specific questions pertaining to each of the ten principles. Due to the specificity of the questions, some of the questionnaires were not applicable to the design of a web-based patient management system.

RESULTS

Experts identified heuristic violations in all ten heuristic principles in the usage of a patient management system. A total of 80 violations were identified in aggregate. However, many of the observed heuristic violations were overlapping similar issues that each expert was checking differently.[12] When needed, evaluators used screenshots and emails to discuss the heuristics violations as references. After discussion of each heuristic principle violations, we were able to remove duplicate results and narrow the violations to a total of 20. Some issues violated more than one heuristic principle. The severity score is based on the 5-level rating scale. Evaluators discussed individual issues in a meeting to determine the severity ratings as a group after the duplicates were removed. The results showed five major issues, nine minor issues, six cosmetic issues. Since the system was already implemented to a relatively functional level, there were no catastrophic issues (severity rating 4) identified by the evaluators.

Observed heuristic violations		
Heuristic Principles	**Observed violations**	**Severity**
Visibility of system status	Difficult to navigate as the menu is only on the top front page	3
	Data entry is not confirmed after input.	3
	Sitemap does not exist	2
	The system is slow	1
Match between system and real world	No icons exist	1
	Decimal points are now allowed	1
User control and freedom	No easy undo function or back button	2
	No default screen customization	2
	No way to rearrange	2
Consistency and standards	Too many notifications for the user to follow. Difficult to prioritize the important tasks	3
	No present choice, all input items are not free text	2
	Menu is not consistent throughout the system	1
Help users recognize, diagnose, and recover from errors	Minimal help or error messages exist in the entire system	2
Error prevention	Patient selection list is too narrow, making it easy to select the wrong patient.	3
	Menus don't always align or are at the same place on different pages	2
	Limited error messages	2
Recognition rather than recall	Color coding is not always consistent	1
Flexibility and efficiency of use	No violation observed	0
Aesthetic and minimalistic design	No icons and all of the selections are words	1
Help and documentation	No help buttons	3
	No clear instructions and step-by step-guide. High learning curve.	2

Table 2. Heuristic evaluation results

Visibility of system status corresponds to informing users on what the system is processing. For example, one of the most concerning violations across multiple heuristics was the lack of navigation assist, a consistent menu, and sitemap. In terms of visibility, users were not easily

informed of where the user is currently in the system. The users have to rely on the web browser function rather than the site navigation to go back or forward. The navigation menu only exists on the front page of the system, such as shown in Figure 2. It leads to multiple issues where the user has to reload or re-enter data, eventually leading to confusion. It also violates consistency and standards where the system should follow platform and industry conventions.

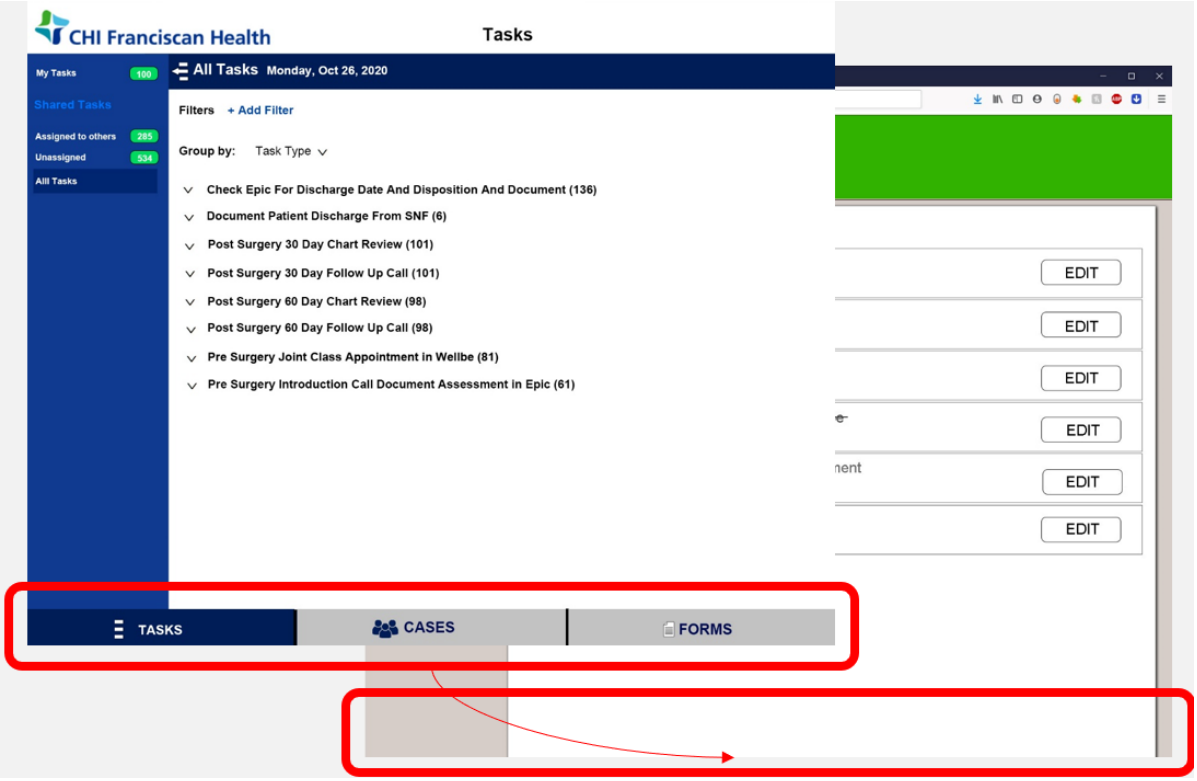

Fig 2. Navigation menu only exists on the main page and disappears on other pages.

From the consistency principle, another major heuristic violation was the number of notifications. Each patient has tasks to be completed in the patient management system. For example, appointment phone calls, follow-up phone calls, surgery confirmation dates, and appointment completion need to be checked in the patient management system and come up as notifications. Each patient has up to ten checkpoints that will come up as notifications if not checked off. Empty items such as patient's demographics, age, and date of birth also are flagged as notifications. Anytime the user opens the patient lists that are assigned will see up to more

than 500 notifications marked to be checked off, shown in Figure 3. Many of those are redundant and do not need to be included as a notification. The high number of notifications cause the users to be easily overwhelmed. It is an issue that also needs to be addressed in the actual workflow rather than heuristics alone. Prioritizing the necessary notifications and a more aggressive selection of notifications will decrease user fatigue and improve the workflow.[13]

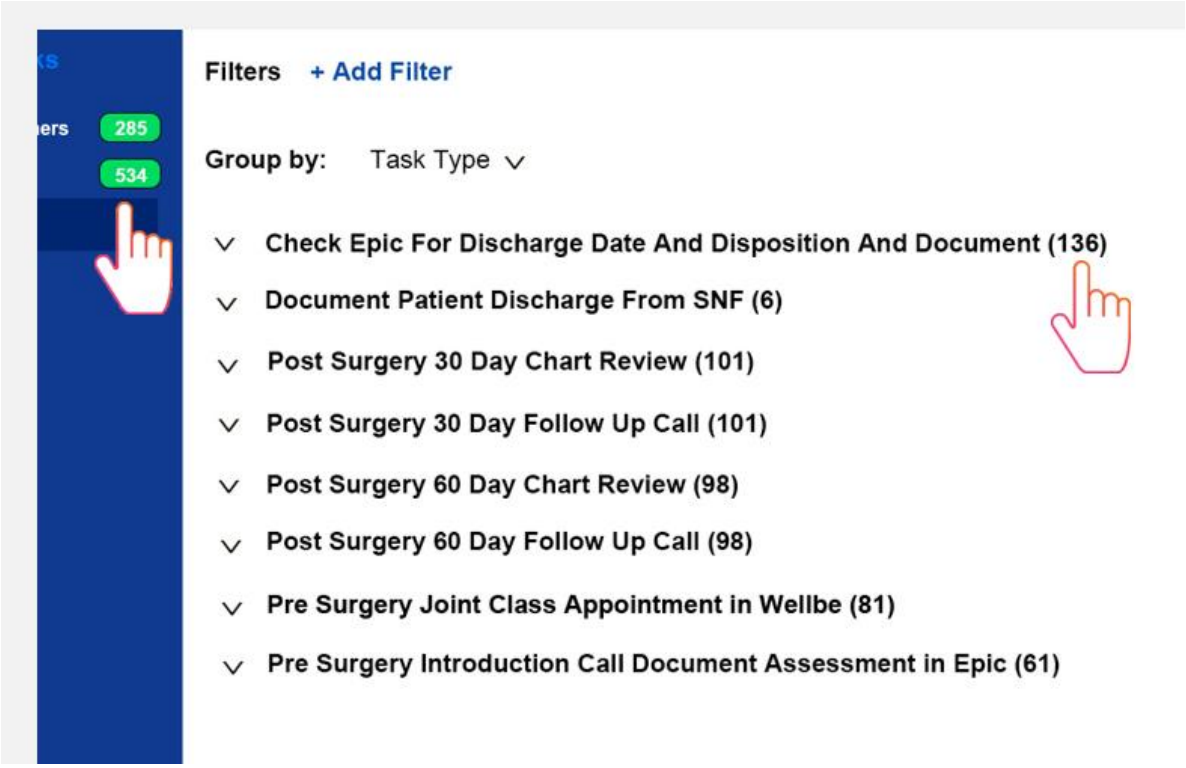

Fig 3. High number of notifications can decrease efficiency

Error prevention principle concerns system design preventing the occurrence of errors. As shown in Figure 4, the patient list is too narrow in the patient management system and has often led to errors in opening up a different patient profile. Combined with the vast number of notifications, a simple error caused by selecting different patients can lead to multiple mouse clicks. This is a barrier to the efficiency of the system.

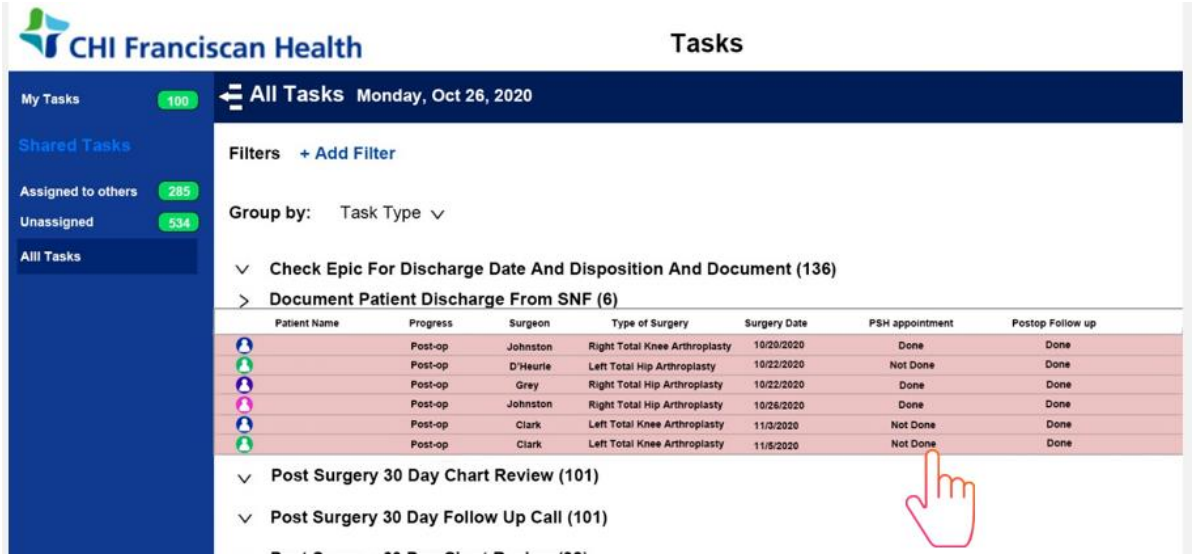

Figure 4. Narrow patient list leading to errors

DISCUSSION

Patient management before and after clinics and surgeries is important part of elective surgery. The patient management system has improved workflow compared to the traditional paper-based manual management. However, the result of this project shows that there are many usability issues within the current electronic patient management system. Fortunately, as the system was already implemented, this post-implementation heuristic evaluation didn't identify any catastrophic issues within the system.

Major usability violations in patient management system were in the principles of consistency, visibility, error prevention. All of these violations lead to large inefficiency of the system and can overburden the user. Other minor violations were also a concern for decreasing efficiency in using the patient management system.

The benefit of utilizing existing users as evaluators was evident as many of the heuristic violations that are identified matched with the actual user experience. The evaluators learned

the importance of heuristic evaluation through this project and will be able to apply their experience in other usability issues. The Xerox checklist helped standardize the process of evaluation across the evaluators.

The findings from heuristic evaluations were gathered and presented to the system developers for further improvement. The system developers also agreed on many of the heuristic violations presented through this project. After the heuristic evaluation and the findings reported to the vendor, the system will need an appropriate update reflecting the recommended heuristic violations. The project evaluators requested the vendor to make changes with the current results. However, systematic changes might take time as it is a third-party health IT system. Once the changes are made and users have learned the new updates, it is crucial to investigate how the changes have improved the usability. A simple usability study that utilizes surveys can evaluate the post-update usability. If time allows, another heuristic evaluation can be considered.

The limitation of the project was that it is based on a small number of evaluators due to the access to the system. Moreover, although the evaluators were experts in their domain, there was only one expert with experience in heuristics evaluation in systems design. Even though the evaluators understood principles of heuristic evaluation and went through multiple education sessions, more experts in heuristics evaluation in systems design might have uncovered further violations that were not fully identified with the current evaluators.

SUMMARY

Utilization of health information technology is frequently adapted in many aspects of patient care. Operation of the perioperative clinic is dependent on an efficient patient management

system. Heuristic evaluation is inexpensive and relatively easy to implement in evaluating the usability of an existing system. Heuristic evaluation by an existing user has an advantage since the users can match current usability issues. Learning heuristic evaluation will help the users that participated in the project since it will give them the tools to articulate the usability issues reflecting on the heuristic evaluation and further improve the system. Using heuristic evaluation with the users who can be trained, health information technology can be further improved.

References

1. Dimick, J. B., Chen, S. L., Taheri, P. A., Henderson, W. G., Khuri, S. F., & Campbell, D. A. (2004). Hospital costs associated with surgical complications: A report from the private-sector National Surgical Quality Improvement Program. Journal of the American College of Surgeons, 199(4), 531–537.

2. Dexter, F., Marcon, E., Epstein, R. H., & Ledolter, J. (2005). Validation of statistical methods to compare cancellation rates on the day of surgery. Anesthesia and Analgesia, 101(2), 465–473.

3. Kash, B. A., Zhang, Y., Cline, K. M., Menser, T., & Miller, T. R. (2014, December 1). The perioperative surgical home (PSH): A comprehensive review of us and non-us studies shows predominantly positive quality and cost outcomes. Milbank Quarterly, Vol. 92, pp. 796–821.

4. Hepner, D. L., Bader, A. M., Hurwitz, S., Gustafson, M., & Tsen, L. C. (2004). Patient Satisfaction with Preoperative Assessment in a Preoperative Assessment Testing Clinic. Anesthesia and Analgesia, 98(4), 1099–1105.

5. Kash, B. A., Zhang, Y., Cline, K. M., Menser, T., & Miller, T. R. (2014, December 1). The perioperative surgical home (PSH): A comprehensive review of us and non-us studies shows predominantly positive quality and cost outcomes. Milbank Quarterly, Vol. 92, pp. 796–821.

6. LeRouge, C., & Wickramasinghe, N. (2013). A review of user-centered design for diabetes-related consumer health informatics technologies. Journal of Diabetes Science and Technology, Vol. 7, pp. 1039–1056.

7. Nielsen, J. (1994, April). Usability inspection methods. Conference companion on Human factors in computing systems (pp. 413-414).

8. Turner-Bowker, D. M., Saris-Baglama, R. N., Smith, K. J., DeRosa, M. A., Paulsen, C. A., & Hogue, S. J. (2011). Heuristic evaluation and usability testing of a computerized patient-reported outcomes survey for headache sufferers. Telemedicine and E-Health, 17(1), 40–45.

9. Doubleday, A., Ryan, M., Springett, M., & Sutcliffe, A. (1997). Comparison of usability techniques for evaluating design. Proceedings of the Conference on Designing Interactive Systems: Processes, Practices, Methods, and Techniques, DIS, 101–110.

10. Hasan, L., Morris, A., & Probets, S. (2012). A comparison of usability evaluation methods for evaluating e-commerce websites. Behaviour and Information Technology, 31(7), 707–737.

11. Pierotti, D. (1995). Heuristic evaluation-a system checklist. Xerox Corporation, 12.

12. Khajouei, R., Peute, L. W. P., Hasman, A., & Jaspers, M. W. M. (2011). Classification and prioritization of usability problems using an augmented classification scheme. Journal of Biomedical Informatics, 44(6).

13. Schnall, R., Bakken, S., Iii, W. B., Carballo-Dieguez, A., & Iribarren, S. (2016). Usabilty evaluation of a prototype mobile app for health management for persons living with HIV. Studies in Health Technology and Informatics, 225, 481–485.