Evidence-Based Usability Principles for
Safe Computerized Provider Order Entry (CPOE) Interface Design

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Abstract

There is a dearth of evidence-based tools to design the safest Computerized Provider Order Entry (CPOE) system possible. An evidence-based list of usability principles for the design of the CPOE interface was developed following a literature review, and validated with the Chief Medical Information Officer and CPOE team at Island Health. The list includes 11 usability principles that can be used to inform ongoing CPOE interface design and evaluation efforts to improve patient safety.

Keywords:

Medical Order Entry Systems, User-Computer Interface.

Introduction

The design of a Computerized Provider Order Entry (CPOE) system is a significant decision factor in reducing medication errors and maximizing safe use. Although the first CPOE system was implemented in 1971, there are several outstanding challenges concerning the usability of CPOE [1] even 47 years later. The underlying issue "appears to be that there is no consolidated source of evidence that provides organizations with tools to design the safest CPOE system possible" [1]. Davis and Stoots' 2012 article on EHR adoption emphasizes that organizations ought to incorporate checklists and tools to minimize any unintended consequences [2]. They suggest simple tools such as checklists act as a highly-effective quality-control instrument that "can prevent potential costly mistakes and even fatal medical errors" [2]. The literature highlights that though there is no "best" method in designing a CPOE system, it requires trial and error work at an organizational level [1]. Sengstack (2010) underlines that there is a need for tools that:

1. Are based on lessons learned and documented in the literature;

2. Can be used to evaluate CPOE systems; and

3. Can be used as a guide for informatics specialists at all levels as the iterative process of improvement continues to cycle [1].

A study from Sunnybrook Health Sciences Centre in Toronto also highlights the importance of organizational commitment to CPOE design to improve efficiency, usability and safety prior to system implementation [3]. Similarly, Yuan et al. (2011) underscores the importance of using a design framework to identify requirements and functional specifications for the User Interface (UI) design of clinical decision support (CDS) [4]. To address the aforementioned recommendations from the CPOE design literature, Island Health developed evidence-based guidelines for the design and evaluation of its CPOE system, as there is currently no comprehensive usability tool to inform CPOE interface design. Three CPOE design tools were developed for CDS Alerts, the CPOE User Interface, and references within CPOE Order Sets. This paper summarizes the usability guidelines developed and adopted by Island Health for the safe and usable design of the CPOE interface. Island Health is a health care organization in British Columbia, Canada with over 23,000 staff and physicians.

Methods

A literature review of CPOE interface design was conducted from November 2017 to January 2018 using Google Scholar. Various search terms were used, including "CPOE design" AND "colour" OR "color"; "CPOE design" AND "font"; "CPOE design" AND "alerts"; "CPOE design" AND "screen"; "CPOE design" AND "icons"; "CPOE design" AND "lists." The inclusion criteria for the literature review included primary or secondary articles that (1) were in English, (2) published between January 2000 and January 2018, and (3) that discussed CPOE design principles. The references of included articles were also mined for relevant articles. Recommendations for CPOE interface design were extracted from the included articles. A thematic analysis of the recommendations was conducted to identify themes from the articles, as well as to develop general usability principles for CPOE interface design. To confirm the congruence of the CPOE interface design principles with general user interface design principles (e.g., Nielsen's ten general principles for interface design), usability heuristics were also reviewed. The resulting CPOE interface design usability principles and sub-principles were iteratively reviewed and refined to produce a final list usability design principles. Face validity was evaluated with the Chief Medical Information Officer (CMIO) and CPOE order set team at Island Health. In addition to a list of usability principles, a designer-centred checklist for CPOE interface design was developed for use by the CPOE team and clinical informatics specialists at Island Health. The checklist presented the usability principles in the form of a question.

Results

In total, thirty articles were included in the literature review, and a list of 11 CPOE interface design usability principles was developed. The list of usability principles for CPOE interface design fall into 11 categories: (1) layout, (2) terminology, (3) use of headings and sub-headings, (4), placement and proximity, (5) general use of colour, (6) use of colour combinations, (7) text style, (8) use of punctuation, (9) use of icons, (10) use of lists, and (11) alert visibility. These principles align with 5/10 of Nielsen's ten general principles for interface design. Due to space limitations, only the sub-principles for Principle 1 (Layout) are presented below. The full (detailed) CPOE interface design checklist with principles, sub-principles, and corresponding literature/evidence will be presented in the poster.

Principle 1: Layout

1. Minimize the layers of screens (to a maximum of 3 layers) to facilitate user's navigation in the system [5].

2. Use visual cues (i.e., colour, font or conspicuous spatial arrangement) consistently. For example, use visual cues within the ordering screen to indicate the difference between the latest results vs. previous results) [5,6,7]

3. Organize the screen elements into logical groups, visually separated by space, alignment and borders; their meaning should be easily recognized by users [5].

Discussion

Island Health's comprehensive and validated list of usability design principles for safe CPOE interface design addresses the current gap in the literature surrounding the need for a consolidated source of evidence for designing safe CPOE systems. The list and check-list of design principles have been adopted by Island Health for its CPOE interface design practices. However, it is interesting to note that the authors did not come across any literature published on the use of special characters in CPOE design, such as asterisks. This was an area of particular interest for Island Health, as asterisks had been previously used in CPOE interface design in the organization. As such, it is unclear if the use of special characters may have any effect(s) on the quality and safety of CPOE interfaces.

Given the iterative process of continuously improving CPOE design, it is important to note that the consolidated list of usability design principles presented in this paper is a "living and breathing" guideline that should be continually updated based on usability-related lessons learned by health care organizations. Based on ongoing CPOE usability evaluations, health care organizations across the globe should regularly document and make recommendations for CPOE interface design to ensure that the design principles are based on emerging best practices in the field. Specifically, pre- and post- evaluation design may be used to evaluate changes in the usability of CPOE before and after adopting the design principles.

A major limitation of this research is that a scoping or systematic review of the CPOE interface design literature was not conducted due to time constraints, and only one database (Google Scholar) was searched. It is recommended that a scoping or systematic review be conducted. Additionally, the list of CPOE usability design principles was only validated with the CMIO and CPOE team at Island Health. The list should be further validated with stakeholders in other health care organizations at the provincial, national, and international levels.

Conclusions

This paper contributes a list of 11 evidence-based usability design principles for CPOE interface design, including principles related to: (1) layout, (2) terminology, (3) use of headings and sub-headings, (4), placement and proximity, (5) general use of colour, (6) use of colour combinations, (7) text style, (8) use of punctuation, (9) use of icons, (10) use of lists, and (11) alert visibility. Specifically, this paper addresses the suggestions made by Sengstack [1] by developing a usability principles tool for CPOE interface design that (a) is based on the literature, (b) can be used to evaluate CPOE usability, and (c) can be used to guide health informatics specialists at all levels in CPOE design and quality improvement. As such, the list of principles has implications for usability evaluation of CPOE; the usability design principles may be applied by health care organizations as a check-list to support the evidence-based design, adoption, ongoing evaluation, and improvement of CPOE interfaces. Given that the authors did not find published literature on the use of special characters (e.g., asterisk) in CPOE interface design, it is recommended that further research be conducted to evaluate the usability and use of special characters to ensure safe CPOE interface design.

References

[1] P. Sengstack, CPOE configuration to reduce medication errors a literature review on the safety of CPOE systems and design recommendations, *Journal of Healthcare Information Management* **24**(4) (2010), 26-34.

[2] C. Davis, & M. Stoots, *A Guide to EHR Adoption: Implementation Through Organizational Transformation*. Chicago, IL: HIMSS, 2012.

[3] J. Chan, K.G. Shojania, A.C. Easty, & E.E. & Etchells, Does user-centred design affect the efficiency, usability and safety of CPOE order sets? *Journal of the American Medical Informatics Association,* **18** (2011).

[4] M.J. Yuan, G.M. Finley, J. Long, J., C. Mills, C., & R.K. Johnson, Evaluation of user interface and workflow design of a bedside nursing clinical decision support system, *Interactive Journal of Medical Research* **2** (2013), e4.

[5] R. Khajouei, M.W. Jaspers, The impact of CPOE medication systems' design aspects on usability, workflow and medication orders. Methods of information in medicine **49** (2010), 3.

[6] A.Z. Hettinger, & R.J. Fairbanks, Recognition of Wrong Patient Errors in a Simulated Computerized Provider Order Entry System, *Academic Emergency Medicine* **1** (2011), S237.

[7] J. Horsky, G. Schiff, D. Johnston, L. Mercincavage, D. Bell, & B. Middleton, Interface design principles for usable decision support: a targeted review of best practices for clinical prescribing interventions. *Journal of Biomedical Informatics* **45** (2012), 1202-1216.

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