HEPS2016 5-7 October 2016 Toulouse, France
Healthcare and Society: new challenges, new opportunities

Usability of Medication-related alerting systems: where do we stand?

Romaric Marcilly[1,*], Elske Ammenwerth[2], Marie-Catherine Beuscart-Zéphir[1]
[1]*INSERM CIC 1403, Lille, Univ Lille Nord de France, CHU Lille, UDSL EA 2694, F-59000 Lille, France*
[2]*Institute of Health Informatics, UMIT – University for Health Sciences, Medical Informatics and Technology, 6060 Hall in Tyrol, Austria*
*e-mail: romaric.marcilly@univ-lille2.fr

Abstract

Context: Medication alerting systems are promising technologies but suffer from a poor usability.
Objective: In order to help manufacturers of medication-related alerting systems improve the usability of their systems, this paper aims to provide evidence-based usability design principles.
Methodology: Two independent analyses of the literature have been performed to identify, on the one hand, usability flaws known in these systems and their consequences and, on the other hand, usability design principles specific to medication alerting systems. Once the design principles synthesized, they have been matched with the usability flaws.
Main results: All in all, 60 usability design principles were matched with usability flaws and their consequences for the users and the work system.
Conclusion: This evidence-based knowledge may help improve the usability of medication alerting systems and ultimately decrease negative unforeseen side effects from the poor usability of that systems.

Keywords: usability, alerting system, evidence, design

1. Introduction

Medication alerting systems are promising technologies. They display in real-time an appropriate pharmaceutical or clinical knowledge at the point of decision-making to help clinicians make informed decisions. Those functions are supposed to "achieve large gains in performance, [to] narrow gaps between knowledge and practice, and [to] improve safety" (Bates et al., 2003). Those systems help improve providers' performance with drug ordering (Jaspers, Smeulers, Vermeulen, & Peute, 2011). The implementation of Computerized Physician Order Entry (CPOE) augmented with such decision support systems enhance healthcare quality and safety (Gandhi et al., 2005), even more so when advanced decision support functions are available (Ammenwerth, Schnell-Inderst, Machan, & Siebert, 2008). However, this intended positive impact is not always achieved (Hunt, Haynes, Hanna, & Smith, 1998; Ranji, Rennke, & Wachter, 2014). On the contrary, acceptance and usage problems, including use errors, are often noticed (Ash, Berg, & Coiera, 2004; Kuperman et al., 2007; van der Sijs, Aarts, Vulto, & Berg, 2006).

A poor usability is a well-known cause of those issues (Bates et al., 2003; Seidling et al., 2011). Usability is the "extend to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specific context of use"

(International Standardization Organization, 2002). When considering a particular category of technology or tool, usability refers to those characteristics of the product that make it easy to use and easy to learn how to use by their intended users. Poor usability may lead users to reject medication-related alerting functions or to adopt workarounds even if this technology is of benefit.

Improving the usability of medication-related alerting systems is a necessity in order to optimize their impact and prevent from usability-induced use errors or other negative outcomes. One way to prevent such usability issues in medication-related alerting systems is to provide manufacturers, designers, evaluators and Human Factors experts with usability design principles that are supported by clear evidence. Currently, existing lists of usability design principles regarding medication alerting functions are scattered across several publications and are mainly based on authors' experience not on empirical evidence.

2. Objectives

The paper at hand presents a project carried out in order to identify and gather usability design principles dedicated to medication-related alerting systems that are supported by evidence from the literature. In line with previous work by Nielsen (Nielsen J., 1994), we aim to match the list of usability flaws with a structured list of usability design principles.

A first step in that direction is to systematically comprehend the usability flaws of medication-related alerting functions and to identify their consequences for the clinicians (usage problems), for the patient and for the work system (negative outcomes).

In a second step, the usability design principles dedicated to medication-related alerting systems that have been published must be identified and organized; finally, they must be matched against the list of flaws in order to assess the coverage of those principles and to illustrate them with actual instances of their violation.

3. Methods

Two independent analyses of the literature have been performed. On the one hand, medication-related alerting systems' usability flaws and their consequences for the clinicians and the work system have been searched through a systematic review process. Then, they have been organized by two Human Factors experts based on existing heuristics and on an inductive classification process.

In parallel, a targeted literature review has been performed in order to identify existing sets of usability design principles specific to medication alerting systems; once identified, usability design principles have been synthesized and organized in a comprehensive way.

Ultimately, the final lists of usability flaws and of usability design principles have been matched together by two Human Factors experts.

4. Results

4.1. Usability flaws of medication-related alerting systems:

A total of 26 papers were included in the systematic review analysis. The analysis of the papers identified 168 instances of usability flaws classified into 13 categories. Those instances represent either violations of general usability principles applicable to any technology, e.g. guidance, workload, explicit control, adaptability, error management, consistency, significance of codes) or infractions specific to medication-related alerting functions (issues of low signal-to-noise ratio, incomplete content of alerts, transparency, presentation mode and

timing, missing alert features, tasks and control distribution, more details in Marcilly, Ammenwerth, Vasseur, Roehrer, & Beuscart-Zephir, 2015).

4.2. Usage problems faced by users

One hundred and eleven instances of usage problems due to reported usability flaws were gathered from the literature. They deal with four main types of consequences for the clinicians: behavioral issues (e.g. increased workload, workarounds), cognitive issues (e.g. information missed, understanding difficulties, use errors, misinterpretation), emotional issues (e.g. annoyance, stress, cynicism) and attitudinal issues (e.g. users questioning the alerting system, alert fatigue/desensitization, more details in Marcilly et al., 2015).

4.3. Negative outcomes on the work system

Twenty instances of negative outcomes were identified that deal with issues of workflow (e.g. increased communication, alert responsibility shifted), issues of technology effectiveness (e.g. expected usefulness not found), issues of medication management process (e.g. diminished efficiency) and issues of patient safety (e.g. decreased quality of care, more details in Marcilly et al., 2015).

4.4. Usability design principles

As for the usability design principles, a total of 9 papers that present sets of usability design principles dedicated to medication-related alerting systems were identified and analyzed. The 9 papers contribute differently to the principles synthesized: collating together several sets of usability design principles found in the literature allows improvement in the variety of the topics represented in each individual set. Overall a large consensus between the authors of the authors appears. Together, they provide a list of sixty usability design principles dedicated to medication-related alerting systems. Those principles are synthesized in six themes: improve the signal-to-noise ratio, fit clinicians' workflow, support collaborative work, display relevant information, make the system transparent and provide useful tools.

4.5. Matching between usability flaws and design principles

The match of the principles present in the literature with a set of usability flaws collected through a systematic review allows identifying limited gaps in those principles: indeed, two principles not found in the literature had to be added and the context of application of 9 principles had to be extended. The organization of the design principles proposed in the present paper represents an improvement with respect to the 9 papers analyzed: even if the principles extracted from those papers have not been changed, instead simply combined and synthesized, the principles are now clearly identified, listed, and organized into a comprehensive, consistent, and structured synthesis.

5. Discussion & perspectives

As far as we know, this is the first project that aims at providing a picture of the evidence available in the literature that support usability design principles dedicated to medication-related alerting systems. This work must be regularly up-dated and completed by analyzing new publications on that topic and other sources of data (e.g. incident reports).

As a result, a list of usability design principles illustrated by actual instances of their violation has been developed. This list has been presented during an international workshop to usability experts, designers, and developers of alerting systems. The audience was enthusiastic about the list of usability design principles supported by evidence because it could help them make

informed design decisions during the design/evaluation process. A design work has been undertaken with members of the audience in order to turn the list into a practical tool to be used during the design/evaluation process of medication-related alerting systems (Marcilly, Monkman, Villumsen, Kaufman, & Beuscart-Zéphir, 2016).

References

Ammenwerth, E., Schnell-Inderst, P., Machan, C., & Siebert, U. (2008). The effect of electronic prescribing on medication errors and adverse drug events: a systematic review. *J.Am.Med.Inform.Assoc., 15,* 585-600.

Ash, J. S., Berg, M., & Coiera, E. (2004). Some unintended consequences of information technology in health care: the nature of patient care information system-related errors. *J.Am.Med.Inform.Assoc., 11,* 104-112.

Bates, D. W., Kuperman, G. J., Wang, S., Gandhi, T., Kittler, A., Volk, L. et al. (2003). Ten commendments for effective clinical decision support: making the practice of evidence-based medicine a reality. *J.Am.Med.Inform.Assoc., 10,* 523-530.

Gandhi, T. K., Weingart, S. N., Seger, A. C., Borus, J., Burdick, E., Poon, E. G. et al. (2005). Outpatient prescribing errors and the impact of computerized prescribing. *J.Gen.Intern.Med., 20,* 837-841.

Hunt, D. L., Haynes, R. B., Hanna, S. E., & Smith, K. (1998). Effects of computer-based clinical decision support systems on physician performance and patient outcomes: a systematic review. *JAMA, 280,* 1339-1346.

International Standardization Organization (2002). *Ergonomics of human-system interaction -- Usability methods supporting human-centred design (Rep N° 16982)*. Geneva: International Standardization Organization.

Jaspers, M. W., Smeulers, M., Vermeulen, H., & Peute, L. W. (2011). Effects of clinical decision-support systems on practitioner performance and patient outcomes: a synthesis of high-quality systematic review findings. *J.Am.Med.Inform.Assoc., 18,* 327-334.

Kuperman, G. J., Bobb, A., Payne, T. H., Avery, A. J., Gandhi, T. K., Burns, G. et al. (2007). Medication-related clinical decision support in computerized provider order entry systems: a review. *J.Am.Med.Inform.Assoc., 14,* 29-40.

Marcilly, R., Monkman, H., Villumsen, S., Kaufman, D., & Beuscart-Zéphir, M.-C. (2016). How to present evidence-based usability design principles dedicated to medication-related alerting systems to designers and evaluators? Results from a workshop. In.

Marcilly, R., Ammenwerth, E., Roehrer, E., Pelayo, S., Vasseur, F., & Beuscart-Zephir, M. C. (2015). Usability Flaws in Medication Alerting Systems: Impact on Usage and Work System. *Yearb.Med.Inform., 10,* 55-67.

Marcilly, R., Ammenwerth, E., Vasseur, F., Roehrer, E., & Beuscart-Zephir, M. C. (2015). Usability flaws of medication-related alerting functions: A systematic qualitative review. *J.Biomed.Inform., 55,* 260-271.

Nielsen J. (1994). Enhancing the explanatory power of usability heuristics. In (pp. 152-158). New-York: ACM.

Ranji, S. R., Rennke, S., & Wachter, R. M. (2014). Computerised provider order entry combined with clinical decision support systems to improve medication safety: a narrative review. *BMJ Qual.Saf*.

Seidling, H. M., Phansalkar, S., Seger, D. L., Paterno, M. D., Shaykevich, S., Haefeli, W. E. et al. (2011). Factors influencing alert acceptance: a novel approach for predicting the success of clinical decision support. *J.Am.Med.Inform.Assoc., 18,* 479-484.

van der Sijs, H., Aarts, J., Vulto, A., & Berg, M. (2006). Overriding of drug safety alerts in computerized physician order entry. *J.Am.Med.Inform.Assoc., 13,* 138-147.