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# How to Present Evidence-Based Usability Design Principles Dedicated to Medication-Related Alerting Systems to Designers and Evaluators? Results from a Workshop

Romaric MARCILLY[a,1], Helen MONKMAN[b], Sidsel VILLUMSEN[c], David KAUFMAN[d] and Marie-Catherine BEUSCART-ZEPHIR[a]
[a] *INSERM CIC-IT 1403; Univ Lille Nord de France ; CHU Lille ; UDSL EA 2694*
[b] *School of Health Information Science, University of Victoria, Canada*
[c] *Department of Planning, Aalborg University, Denmark*
[d] *Department of Biomedical Informatics, College of Health Solutions, Arizona State University, Scottsdale, AZ, United State*

**Abstract.** Medication alerting system use errors and lack of adoption are often attributed to usability issues. Previous work has used evidence from the literature to reveal usability principles specific to medication alerting systems and identify potential consequences of violating these principles. The current study sought to explore how best to convey these principles to designers and evaluators of these systems to facilitate their work. To this aim, a workshop with 19 participants was used to generate ideas and opinions on how to deliver these topic-specific design principles in a way that would be most helpful for them. Participants generated ideas for how (e.g., a collaborative, continuously updated forum) and what (e.g., illustrations, checklists, evidence sources and strength, consequences of violations) information is most useful to disseminate usability principles for medication alerting systems. Participants, especially designers, expressed desire to use these principles in practice and avoid previously documented mistakes and therefore make design and evaluation of these systems more effective and efficient. Those insights are discussed in terms of feasibility and logistical challenges to developing the proposed documentation). To move this work forward, a more collaborative approach of Human Factors specialists in medical informatics is necessary.

**Keywords.** Decision support, clinical; Human engineering; Usability; Ergonomics; Human Factors; Alerting system; Medication; Design; Evaluation

## 1. Introduction

Medication alerting systems display in real-time an appropriate clinical or pharmaceutical 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" [1]. Indeed, alerting systems help improve providers' performance with drug ordering [2]. There is also evidence that Computerized Physician Order Entry

[1] Corresponding Author: romaric.marcilly@univ-lille2.fr

augmented with such functions enhance healthcare quality and safety [3], even more so when advanced decision support functions are available [4]. However, other studies reveal that their intended positive impact is not always achieved [5;6] and that those systems often face acceptance and usage problems [7-9]. Poor usability is a well-known cause of those issues [1;10].

To prevent problems originating in usability issues, usability must be considered throughout the design and evaluation of technologies. However, applying processes and methods is necessary but not sufficient to designing usable technology: usability knowledge, especially of usability design principles, is required to efficiently design health technology [11]. Unfortunately, information about those principles is neither stable nor structured. Accumulation of structured evidence regarding usability design principles for medication alerting systems is therefore critical to improve their accuracy and efficiency [12]. This knowledge will also promote illustrated design solutions of medication alerting systems and optimize their usability and ultimately decrease the risk of usability-induced use errors, which have potential patient safety implications.

## 2. Background: seeking evidence supporting usability design principles

There is large amount of publications about the usefulness and acceptance of medication alerting functions supporting the prescribing of medications by the physician. In previous research, a systematic review (from 2015) of usability flaws of medication alerting systems identified a total of 168 instances of usability flaws. Most of them dealt with low signal-to-noise ratio, alert content, function's transparency, alerts' appearance, tasks and control distribution and alert features issues [13]. A secondary analysis revealed the consequences of those flaws on the user (usage problems) and negatives outcomes on the work system noticed by the authors of included studies. A total of 111 instances of usage problems (e.g., increased workload, misinterpretation, decision interruptions, alert fatigue, questioning the alerts' validity) and 20 negative outcomes were extracted (e.g., communications issues, shift in alerts' responsibility, and patient safety issues) [14].

Usability design principles dedicated to medication-related alerting systems were searched in the literature and matched with the flaws identified. Six areas of design principles were found: improve the signal-to-noise ratio, fit the clinicians' workflow, support collaborative work, display relevant information, make the system transparent and provide useful tools. As a result, a list of usability design principles illustrated by actual instances of their violation was developed.

With the evidence supporting usability design principles dedicated to medication alerting systems established, the question of its usefulness for designers and evaluators of alerting system must be answered. This paper presents the results from a workshop organized to gather opinions on the usefulness of those principles and on "how to present evidence-based usability design principles to practitioners during the development/evaluation of medication alerting systems?"

## 3. Methods

We took the opportunity of an international medical informatics conference in 2015 to organize a 2-hour workshop. First, participants answered a short questionnaire to get

information on their background. They had to self-estimate their experience with alerting systems and with usability. Then, the audience was introduced to the usability issues in medication alerting systems and with the need for evidence. The results obtained during the previous studies were presented. To illustrate them and to help participants understand their content, a printed subset of design principles and related usability issues was provided to the participants.

In order to get feedbacks as exhaustive as possible regarding both the design and evaluation contexts of use of the list of principles, two working groups were formed: one focusing on the design context and the second on the evaluation one. Participants were free to choose the context that best suited their work and expertise. In each group, one participant was named secretary and recorded the ideas expressed during the discussions. One author facilitated each group and guided the discussion by asking questions such as: under which form the knowledge could be used for designing/evaluating? Which information should be displayed to the designers/evaluators? How should the information be presented?

In order to illustrate their proposals, participants were invited to share their experience. At the end of the workshop, the design and evaluation working groups were recombined and secretaries presented summaries of the proposals of their respective group to the whole audience. Notes taken by the secretaries were complemented by facilitators' notes and were synthesized by one author (RM).

## 4. Results

Nineteen practitioners and researchers took part in the workshop (cf. Table 1). Participants rated their knowledge of the usability field from average up to very good; as for the alerting system's knowledge, the estimations were ranged from no knowledge to a very sound knowledge.

**Table 1.** Number of participants according to their profile. The sum is over 19 because 2 participants had 2 profiles: one "physician" was also "designer" and one "clinician" works also in "technology assessment".

| Profiles of participants | n |
|---|---|
| Computer scientist / Developer / Designer | 11 |
| Physicians / Clinicians | 4 |
| Cognitive psychologist / Human factors expert | 4 |
| Technology assessment expert | 1 |
| Patient safety expert | 1 |

Participants expressed that the list of design principles, presented as a set of guidelines or a checklist, could be very useful for designing and evaluating alerting systems. Some suggested it could be used also to support the procurement process to compare several system against a list a usability criteria. Participants who recently had to design an alerting system (n = 6) were the most enthusiastic: they found that the proposed list of design principles could have helped them save time during the project by preventing known design/implementation problems. More precisely, they said that the list could have helped them to interpret and understand criticisms expressed by physicians who used their prototypes. Further, participants listed characteristics that would make the use of the principles easier:

- The list should be printable and downloadable to be used in various situations.
- The list should be organized hierarchically with high-level principles (or meta-usability criteria) broken into sub-principles (or specific criteria). This

hierarchy may be presented into sub-menus displaying several design options: once an option chosen, other related sub-options are presented.
- For evaluation purpose, the list should be adapted to the context of evaluation: e.g. if the evaluation is about cue-cards representing alerts, only principles related to the display of the content of the alert should be presented.

Participants highlighted that principles should be presented along with:
- Their justification (e.g. potential consequences of their violation): it would help designers /evaluators to inform other stakeholders of the consequences of ignoring the usability design principles.
- Links to the studies proposing the principles and the evidence.
- The evidence level for users to judge the priority of the principles.
- Illustrations of the desirable features by "visual examples" of the good and bad ways to apply the principles (e.g. screenshots of systems known to be successful). In the examples, the good applications of the principles and/or their violations should be highlighted.

In order to support the integration of the usage of the list of design principles within their practice, participants asked for:
- Links to general usability principles (e.g. Nielsen's heuristics) to get a deeper knowledge on desirable overall usability characteristics.
- Some usability principles have indirect consequences on how to build the database used to trigger the alert. Therefore, information on those databases should be provided with the principles in the design context at least.
- Information on the usability evaluation process (e.g. recommendations for implementing the user-centered design methods), even in the design context. Also scenarios of test for various contexts of evaluation should be provided.

Finally, some participants pointed out that the tool gathering the design principles should be collaborative and support development (e.g. through a wiki or a forum): other practitioners and researchers could update and enhance its content.

## 5. Discussion

The present study questioned the usefulness of a list of evidence-based usability design principles dedicated to medication alerting systems. We gathered opinions of practitioners and researchers through a workshop. The main results reveal that the list could be useful especially for designers. Participants also highlighted that such a list should be presented with other related items (e.g., potential consequences of violating the principle, source of the evidence, visual examples of good design vs. poor design) in order to help users understand the purpose of the principles and how to apply them. Part of those related items is already known: instances of their violations, their consequences on the users and the work system, and studies of reference [13;14]. Participants insisted on their need of visual illustrations of the proper and erroneous applications of the principles. Those illustrations are not easy to provide. Providing screenshots may face legal issues: manufacturers are usually not prone to authorize the use of their systems for illustrative purpose. Developing mock-ups based on the design principles could be an option worth exploring. However, mock-ups hardly provide information as rich as actual systems. In summary, work is still needed to be able to

provide the right level of "visual illustration" that will help users understand the purpose of the principles.

Lille CIC-IT is currently developing a web database for the principles dedicated to medication alerting systems based on the results presented above. There should be made similar attempts for other types of health technologies. However, this approach is very time-consuming. Participative approaches are required: the whole human factors for medical informatics community supported by international organizations, should be involved in building the knowledge, in making it usable and accessible, and in maintaining it over time. However, the process of managing and controlling the knowledge implemented has to be defined.

Developers and evaluators ask for evidence-based knowledge incorporated within a tool to support their usability practice and to ultimately decrease the risk of usability-induced use errors. For their needs be completely fulfilled, several challenges must be overcome (e.g. design of visual illustrations). Nonetheless a large part of the knowledge needed is already available (e.g. evidence).

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