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Usability flaws of medication-related alerting functions: A systematic qualitative review

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ABSTRACT

Introduction: Medication-related alerting functions may include usability flaws that limit their optimal use. A first step on the way to preventing usability flaws is to understand the characteristics of these usability flaws. This systematic qualitative review aims to analyze the type of usability flaws found in medication-related alerting functions.
Method: Papers were searched via PubMed, Scopus and Ergonomics Abstracts databases, along with references lists. Paper selection, data extraction and data analysis was performed by two to three Human Factors experts. Meaningful semantic units representing instances of usability flaws were the main data extracted. They were analyzed through qualitative methods: categorization following general usability heuristics and through an inductive process for the flaws specific to medication-related alerting functions.
Main results: From the 6380 papers initially identified, 26 met all eligibility criteria. The analysis of the papers identified a total of 168 instances of usability flaws that could be classified into 13 categories of usability flaws representing either violations of general usability principles (*i.e.* they could be found in any system, e.g. guidance and workload issues) or infractions specific to medication-related alerting functions. The latter refer to issues of low signal-to-noise ratio, incomplete content of alerts, transparency, presentation mode and timing, missing alert features, tasks and control distribution.
Main conclusion: The list of 168 instances of usability flaws of medication-related alerting functions provides a source of knowledge for checking the usability of medication-related alerting functions during their design and evaluation process and ultimately constructs evidence-based usability design principles for these functions.

1. Introduction

Computerized Clinical Decision Support (CDS) functions may have a noteworthy impact on medication management safety [1]. Several studies have shown that they help to improve antibiotic use [2], drug dosing [3,4], clinical practice [5,6] and patient outcomes [7]. However, implemented systems may face acceptance problems [8,9] that partly originate from poor usability. Poor usability may lead users to reject CDS functions or to adopt workarounds even if the CDS functions are of benefit.

Usability is "the extent to which a product can be used by specified users to achieve specified goals effectively, efficiently and satisfactorily within a specific context of use" [10]. Usability goes beyond the features of the Graphical User Interface (GUI; e.g. legibility of texts), and deals with the functionalities of the product and with the fit between the system behavior and the needs of the users' [11].

Therefore, along with the study of the GUI characteristics, usability includes the analysis of the way in which the system responds to users' actions, of the organization and accuracy of the knowledge incorporated, and of the availability of functions

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supporting users' tasks. Poor usability of systems arises from the existence of usability flaws. Flaws are violations of usability design principles, and are additionally known as usability heuristics or usability criteria [12–15]. They may have an impact on users' experience with the system (usage problems) and generate negative outcomes in the work system (e.g. performance/patient safety issues) [16]. The present review focuses on usability flaws.

Improving the usability of CDS functions is a necessity [17]. In the broad sense, according to [18], computerized CDS interventions refer to a wide range of tools: forms and templates (e.g. to support proper drug order documentation), relevant data presentation (e.g. to support optimal decision making), proactive drug order suggestions and order sets (e.g. to ensure that a clinical situation is completely addressed), protocol supports/clinical pathways (e.g. to avoid omissions in the care process), reference information/guidance (e.g. to address known information needs) and alerts (e.g. to prevent errors due to lack of knowledge) [18,19]. These categories of tools are not exclusive, for instance, alerts may be integrated in order sets or in protocol supports. Within the whole range of available computerized medication CDS systems, alerting functions are known to face serious usability issues [17,20].

One way to prevent such usability issues is to provide manufacturers and Human Factors experts with evidence-based usability design principles [16]. Currently, existing lists of usability design principles regarding medication alerting functions are not based on evidence but rather on expert consensus (e.g. [17]) or targeted review (e.g. [19,20]). This study is part of a project that aims at contributing to the emerging knowledge on usability design principles to complete the existing lists and identify the usability design principles that are supported by evidence in the literature. A first step in that direction is to systematically comprehend the usability characteristics of medication-related alerting functions.

The present systematic review focuses on medication-related alerting functions and addresses the following question: "What are the usability flaws of medication-related alerting functions identified in published studies?"

2. Method

This systematic qualitative review complies as far as possible with international methodological guidelines [21,22] as well as with reporting recommendations [23].

2.1. Eligibility criteria

This review considered only original studies reporting usability flaws and published after 1980 in peer-reviewed journals or conference proceedings. Only English and French speaking papers were included. Three eligibility criteria were defined:

- Only medication-related alerting functions supporting the prescribing of medications and used in general hospital or in primary care general practice were included. Surgery, dentistry, anesthesiology, emergency were excluded because the organization of the medication management of those wards is different from the general hospital with respect to the types of clinicians involved and the nature of the work process. Pathology or diagnosis management alerting functions were excluded when they did not include features to support medication decision-making. Alerting functions dedicated to the patients as primary end-users were also excluded.
- Usability studies as well as socio-technical studies and impact studies addressing (at least partially) usability issues were included. Only papers judged to have high quality reporting of the study were kept (see Section 2.5 for details). Studies on more than one system were included if the results presented insights for each system separately.
- The review targeted studies that reported usability flaws in a descriptive and objective way. This excluded all studies reporting perceived usability assessment or feelings/opinions e.g. collected through usability questionnaires.

2.2. Information sources and search

Information was searched for in on-line references databases. Themes of searched papers are at the intersection of two domains: "health technologies" and "ergonomics". Therefore three databases dealing with those themes were chosen; PubMed, Scopus and Ergonomics Abstract. This search was completed by searching references in the reviewed papers.

Two sets of key terms were defined: on "alerting functions" and on "usability" (cf. Table 1). In each set, terms were combined with the "OR" operator. Both sets were then combined with the "AND" operator (cf. Appendix 1 for the complete queries). As the Ergonomics Abstracts database is dedicated to Human Factor topics, only the first set of terms was searched. The language was restricted to English/French, publication date after 1980, and type of journals to medical journals. Searches were performed on the 22th April 2012 and updated on the 25th June 2013.

2.3. Study selection process

The study selection was performed by usability experts with high expertise in Human Factors applied to health informatics and who had previous experience with medication management systems, CDS and alerting functions. The selection process is represented in Fig. 1. At each step of the selection, the review process was over-inclusive; if in doubt, the item was included for an analysis at the next step. Agreement scores were calculated between reviewers on their inclusion/exclusion decisions based on the eligibility criteria (cf. 2.2).

One reviewer (RM) excluded duplicate publications, non-original studies and non-peer-reviewed papers. Then, two reviewers (RM & MCBZ) screened the title of the papers, after a joint training session on 77 papers that were chosen at random from amongst all the papers, the reviewers screened 471 randomly selected papers

Table 1
Key terms used in the queries according the database searched.

	PubMed	Scopus	Ergonomics abstracts
Alerting functions terms	Computerized physician order entry, CPOE, Clinical decision support, CDSS	Medical order entry systems, Medication alert system, Computerized physician order entry system, CPOE, Decision Support Systems, Clinical, Clinical decision support systems, CDSS	Medical order entry, Medication alert,
Human Factors terms	User–computer interface, Human engineering, Risk factors, Humans, Usability	User–computer interface, Human engineering, Risk factor, Human factor, Usability, Human–computer interaction	Not applicable

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