Usability Studies on Interactive Health Information Systems; Where Do We Stand?

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Abstract. This paper discusses the preliminary results of a systematic review of the literature on applied usability studies of health information systems in the period 1990 to 2006. Abstracts were included when they described an evaluation of the usability of a health information system. To gain insight into usability methods applied and their properties we constructed a framework to analyze the studies. The framework includes objectives, designs, number of participants, user-profiles, settings, medical domain, and type of health information systems evaluated. Fifty-two Papers were included in the review. Findings show that from 2002 an increasing trend can be observed of publication of usability studies. Most studies discuss summative usability results on working systems thereby focusing on systems' adoption problems. Formative usability studies lack a uniform way to describe how study results contributed to the system's iterative development cycle.

Keywords. User Interfaces, Assessment-Evaluation, Health Professional Workstation

Introduction

In healthcare, clinicians manage sensitive and complex information while working in a highly agile work environment. A critical prerequisite for computer systems to be successfully implemented in such settings is that their interactive user interfaces are streamlined to the working practices of their users and are highly usable [1]. To verify and optimize system usability, a variety of analytical and empirical methods from the area of usability engineering and human-computer-interaction have been adapted to and applied in healthcare system evaluation studies [2, 3]. It is argued that applying these methodologies to healthcare information systems design and evaluation will lead to an understanding of clinicians’ reasoning and processing of health care concepts crucial in system re-design efforts [4]. The diversity in usability methods and type of health care system to which these methodologies have been applied has made it difficult to gain a clear overview on what insights on healthcare systems development have been acquired and where challenges for future usability studies remain. A detailed
investigation of published usability studies may reveal the benefits and trade-offs of usability methods applied in the healthcare environment and give insight into how information needs of targeted health care users may or may not be reached. In this paper we present the preliminary results of a systematic review on applied usability studies on healthcare information systems. The aim is to provide clear insight into what methodologies and study designs have been used in usability studies on health information system development and evaluation. Further research will focus on measured outcomes in usability studies and insights gained into the merits of applied usability studies to health information system development and implementation.

1. Research methodology

1.1. Background definitions

All definitions of computer system usability speak of multiple components [4,5,6]. As Nielsen states, it is important to realize that usability is not a single, one-dimensional property of a computer user interface alone [5]. Usability answers the question on how well users can use an information system’s functionality, concerning learnability, efficiency of use, memorability, errors and satisfaction. Kushniruk and Patel define usability as the capacity of a system to allow users to carry out their tasks safely, effectively, efficiently and enjoyably. In this review we use both definitions for overall coverage of studies describing a usability evaluation study [6].

For the definition of health information systems, the authors adopted the definition of Ammenwerth and de Keizer: ‘all computer-based components which are used to enter, store, process, communicate, and present health related or patient related information and which are used by health care professionals or the patient themselves in the context of inpatient or outpatient patient care’ [7]. This definition includes laboratory information systems, decision support systems, hospital information systems, management information systems, medical record systems, online systems, radiology information systems and reminder systems. In this review we however focus on interactive health information systems with a computer screen; human-computer interaction is possible by a user-interface. Community networks, databases, MEDLARS and geographical information systems were excluded from the review.

1.2. Selection procedure

MEDLINE and EMBASE were systematically searched on April 21, 2005 and May 2, 2006 using a combination of the following Medical Subject Headings (MeSH terms) information system, evaluation studies and the keywords directly associated with the definition of “usability”. Excluded MeSH terms Community networks, databases, MEDLARS, geographical information systems. Additional searches with the same keywords were performed by searching ScienceDirect and Proceedings of AMIA and IEEE. Reference lists of articles were also reviewed for relevant articles. Dutch and English publications, published between January 1990 and February 2006, were included. This resulted in 212 articles. To gain insight into the general features and quality of the published usability studies on health information systems between 1990 en May 2006 article inclusion was based on abstracts. The abstracts were reviewed and classified (inclusion, exclusion, unclear) independently by the first and second author.
Studies were included if in the abstract mention was made of (1) a computer system that complied with the stated description of interactive health information system and (2) an evaluation study in which aspects of system usability were assessed. After reviewing the abstracts 52 articles met the inclusion criteria [8]. Inclusion of more than one article on a single system was done if the articles described distinct evaluations. The inter-rater agreement between reviewers on the eligibility of studies for the systematic review was $k=0.81$. All disagreements were resolved by reviewing and discussing the complete articles ($n=19$) before deciding to include or exclude them.

1.3. Framework for article review

Each included article was first rated on general characteristics: year/month of publication, authors and source/journal. To analyze the described usability studies a framework was developed by the authors based on definitions from the field of evaluation studies and terms applicable to usability studies as described by Patel, Kushniruk, Nielsen, and Wyatt [4,5,6,9]. The framework includes the following dimensions (1) study objective(s): formative (valuation is done parallel to system development and implementation, results are fed back to system design) / summative, (evaluation is done after system introduction is completed; aim is to check whether aims of system implementation are fulfilled), subjectivist (mostly qualitative approach) / objectivist (mostly quantitative approach); (2) study design (within group/single group/between group); (3) setting (laboratory, in practice, field study); (4) methods (observation, questionnaire, survey, interviews, logging, GOMS, pluralistic walkthrough, cognitive walkthrough, guideline checklists, screenshot analysis, heuristic evaluation, cognitive task analysis, additionally mentioned methods), (5) outcome measurements, (6) number of participants, (7) user-profiles (subjects computer expertise, subjects expertise in work domain, subjects role in workplace), (8) role of researcher (neutral agent, system developer, add.), (9) medical domain and (10) type of health information systems described in the studies.

The two reviewers independently extracted the information from all included articles. The raw agreement of extracted information was 89%. Disagreements were 100% resolved by consensus. Extracted information was then entered in a Microsoft Access© database specifically constructed by the authors, based on the framework, to analyze the data.

2. Results

2.1. General characteristics of included studies

Of the total of 52 included articles only 14 (39%) were published before January 2002. 19 (37%) of the selected studies were drawn from Conference Proceedings in 2002 and 2004. Of the 52 studies 7 (13%) were set as ‘field study’, 31 (60%) ‘in practice’, 5 (10%) ‘laboratory study’, and in 9 studies (17%) the specific study setting was not mentioned, nor could be deduced. Systems evaluated were web-based systems (8%), PACS (6%), electronic patient records (6%), electronic medical record systems (8%), computerized physician order entry systems (8%), decision support system (8%),...
of which the majority of systems evaluated were specialized systems such as clinical reminder systems, and dental systems. Of the described usability studies concerning health information system evaluation, 34 (65%) used a single group design, 9 (17%) used a between group study design, 1 (2%) used a within group study design, and 8 (15%) only mentioned the methods applied and results without an explicit description of the study design. Studies were divided in formative studies (27%) and summative studies (73%). Table 1 specifies the studies’ objective in potential study design combinations; formative/summative studies with a subjectivist (mostly qualitative) or objectivist (mainly quantitative) approach. If multiple usability methods were applied with a differing study design, this is shown by an arrow \(\rightarrow\). If the first usability analysis was more qualitative and the second analysis more quantitative then this is shown by subj. \(\rightarrow\) Obj, and vice versa.

2.2. Applied methodology in the usability study description

In only 8 (15%) of the studies, a singular evaluation method was used, of which 6 applied a usability survey aimed at measuring end-user satisfaction with the system. Cognitive analysis methods such as the Think Aloud (TA), and Cognitive Task analysis (CTA) were combined with a heuristic analysis (Heu) (based on usability guidelines), logging (Log) (log file analysis) and use in real practice by observation of real life working situations (Obs) and (semi-structured) interviews (Int). All methods with exception of the ‘Cognitive Walkthrough method (CW) have been applied in both formative as well as summative studies. In non of the selected studies the usability methods: ‘pluralistic walkthrough’, ‘screenshot analysis’ and ‘usability guidelines’ had been applied as a usability data collection method. In 8 studies ‘focus groups’, ‘contextual inquiry’, ‘expert evaluation’ and ‘activity analysis’, and ‘remote web-based usability testing’ were mentioned as complementary usability methods applied in the
system design phase. Most studies (73%) perform usability evaluations on working systems, in order to detect system errors or analyze usability issues related to end-user satisfaction with system use. Table 2 shows the percentage of studies applied in the 5 stages of iterative system development. Only 19% of the studies actually apply usability methods within the specification/development phase. Non of these studies accurately described the collected results and how the results of the usability study were applied in system optimization or re-engineering.

3. Discussion

In published literature it has come to the fore that the ultimate acceptance or rejection of health information systems largely depends on the degree of system usability [10,11]. From 2002 an increasing trend can be observed of publications on usability studies of health information systems which indicates that usability is gaining more notice in evaluation research. It appears that usability evaluation studies on healthcare information systems indeed mostly aim at gaining insight into system aspects that influenced its adoption as 60% of the performed usability studies take place ‘in practice’ and 73% describe summative results. Though it is also widely acknowledged that usability studies are crucial in designing user interfaces of health information systems that fulfil clinicians’ needs [11] only 23% percent of the usability studies were performed as part of a system development cycle. It is clear that a qualitative usability methodology is time-consuming and integrating its results in a system’s iterative development cycle is difficult. However, these results seem to point out that usability experts are called in too late in a system development process. Use of healthcare information systems is very sensitive in regard to health hazards of patients. The additional strain placed on clinicians by a new system may be a nuisance, but more importantly it can lead to dangerous errors. If usability experts are included from the beginning of the development process not only the iterative design cycle may shorten, more importantly new insights might be acquired on general system design aspects that might potentially lead to errors in healthcare. Until now, only few studies (3%) actually relate system usability issues to the potential of errors in healthcare caused by system use [3].

The rapid and continuous developments of commercially based health information systems make it even more important that these systems should be safe, with clear and

<table>
<thead>
<tr>
<th>System development phase</th>
<th>Perc. Usability studies</th>
<th>Applied Methods</th>
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<tbody>
<tr>
<td>Requirements phase</td>
<td>4%</td>
<td>Think Aloud, Interviews, User-requirements questionnaire</td>
</tr>
<tr>
<td>Specification/development phase</td>
<td>19%</td>
<td>Heuristics, Cognitive Task Analysis, GOMMS</td>
</tr>
<tr>
<td>Implementation/release phase</td>
<td>0%</td>
<td>-</td>
</tr>
<tr>
<td>Post-implementation analysis for insight into the need for system re-engineering or end-user satisfaction</td>
<td>73%</td>
<td>Surveys/developed questionnaires, Cognitive Walkthrough, Logging and Observation of work practices, Heuristics, Think Aloud</td>
</tr>
<tr>
<td>Additional: system selection of commercially build system</td>
<td>4%</td>
<td>Comparative methods; survey/requirement questionnaire</td>
</tr>
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Table 2. Percentage of selected studies per system design phase in iterative system engineering.
validated studies on their usability, preferable based on scientific insights into usability and general metrics on system safety aspects.

Next to this, the performed evaluation studies which describe the assessment of system specific usability aspects lack a uniform description of the study and of its results. As most studies offer practical insights into system adoption aspects the potential merits of using the various methods are still unclear. For example, when does the Think Aloud or Cognitive Walkthrough method offer the best results? The theory of triangulation [12] proposes that methods and approaches should be combined for better validation of study results. Of all analyzed studies, 23% combined two or more qualitative methods and 44% combined qualitative usability methods with survey and interview analysis. However, a uniform description of usability study results and applied methods is needed in order to gain insights into general usability guidelines for healthcare system development.

4. Conclusion

Integration of usability in the development processes of health care IS is challenging. Insights into where usability has effectively been integrated in design and evaluation may lead to the development of new metrics on which to evaluate healthcare user interfaces. Future analysis of studies of the systematic review will focus among other things on the applied strategies of usability methods on different types of healthcare information system and the experiences and lessons learned of combined methodologies in usability evaluation studies.

References