Assessing the usability of web-based applications for diabetes care

Maria Gheorghe-Moisii[1], Marilena Ianculescu[1], Costin Pribeanu[1,2]

[1]National Institute for Research and Development in Informatics - ICI Bucharest

Bd. Maresal Averescu, nr.8-10, Bucharest, Romania

[2]Academy of Romanian Scientists

{maria.moisii, marilena.ianculescu, costin.pribeanu}@ici.ro

ABSTRACT

In the last years, software applications for medical care, including the guided self-management of medication, have known a continuous expansion. As such, there is a growing interest in the usability of these applications. A typical category of patients that need support for the self-management of medication and life style are the diabetics. This paper aims to present three case studies of usability evaluation of web-based applications for diabetes care. The evaluation results revealed several important usability problems that are mainly related to the user guidance and user effort.

Keywords

Usability, usability inspection, usability heuristics, diabetes care, online medical centers.

INTRODUCTION

In the last decade, the software applications for medical care have known a continuous expansion. A huge number of online medical centers exists that provide information, various medical devices, and online support for the self-management of medication. As such, there is a growing interest in the usability of these applications. [1, 4, 6, 8, 14, 17] .

However, there are few evaluation studies targeting usability as the main concern and following a usability evaluation method that uncover usability problems, such as user testing or usability inspection. Most of the existing studies are evaluation both functionality and usability. The approaches are more oriented towards identifying general usability issues via qualitative studies or user satisfaction questionnaires than to uncover and report usability problems.

This paper aims to present three case studies of usability evaluation of web-based applications for diabetes care. A task-based usability inspection has been used for this purpose. The evaluation has been carried on in the context of a national research project aiming to develop online support and / or monitorization of patients with chronical diseases. For the explanation and classification of usability problems a set of usability heuristics and associated guidelines has been used.

The rest of this paper is organized as follows. The following section presents some related work in the area of usability evaluation of the online medical centers. In section 3, the case studies are presented and the results are discussed. The paper ends with conclusion, and future work.

RELATED WORK

Usability evaluation

The ISO standard 9241-11 [10] defined usability as the extent to which a product can be used by specified users to achieve specified goals effectively, efficiently and with satisfaction in a specified context of use. Usability evaluation can be formative or summative [21].

Formative usability evaluation aims to identify usability problems, help the developers to fix the problems and, this way, improve the usability of the interactive system. A usability problem has been defined by Nielsen [16] as any aspect of the user interface which might create difficulties for the user.

The usability problems are rated according to the potential effect on user's task on three severity levels: major (failure to accomplish the task goal or a significant loss of data or time), moderate (important impact on task execution but the user is able to find a way), and minor (irritating the user but the impact on the task's goal is not important):

There are two main categories of usability evaluation methods: the inspection methods (expert evaluation) and the user testing. The inspection methods can be carried on in the early stages of the development process, are less expensive but more subjective (depend on the evaluator's expertise). In this case, the usability problems are anticipated (not real) [5].

The usability inspection provides quantitative measures (number of usability problems in each category) and qualitative measures (description of usability problems). For the developers, a detailed description of each usability problem (explanation, anticipated difficulties, context, causes, and suggestions for fixing) is very important since it helps the improvement of the user interface.

There are a lot of usability inspections, from which the most widespread is the heuristic evaluation proposed by Nielsen & Molich [15]. The evaluation is done against ten usability principles (heuristics). Heuristic evaluation has been criticized because it is system-centric and mainly oriented towards fault finding than to the task goal [5, 6, 11]. Another shortcoming is the lack of a task-based approach, which is limiting the reproducibility of the evaluation and the comparability of the results.

An inspection method that is task oriented is the heuristic

walkthrough [20]. Another task-based inspection method has been proposed by Pribeanu et al. [18]. In this method, the usability problems were explained and documented by using an extended set of usability heuristics that integrates the heuristics of Nielsen & Molich [15] with the ergonomic criteria of Bastien & Scapin [2]. Recently, the heuristics have been revised and grouped under four ergonomic principles: user guidance, user effort, user control and freedom, and user support [19].

Usability of online medical centers

Several studies have been carried that are reporting on the functionality and usability evaluation of the software applications for diabetics.

Lyles et al. [13] conducted a review of usability studies and noticed that in the last two years of the period (2009-2013) there is an increase in this type of papers. Most studies are using qualitative assessment (focus group or interview) and questionnaires. Their review analyzed in more detail 23 studies out of 135 identified. They found 3 only five studies concluding with a list of unique usability problems that have been identified by using think-aloud (3), cognitive walkthrough (1), and heuristic evaluation (1).

The main usability problems identified by the review of Lyles et al. [13] were: use of medical jargon and terminology, information overload, poor user friendliness, redundancies in layout, functionality, and content, time consuming access to information, cumbersome interface, mislabeling of site functions, and openness to data error.

Another review targeting the usability of medication-alerting functions has been conducted by Marcili et al. [14]. They selected 26 papers out of 454 based on a full-text review then analyzed and grouped the general and specific usability issues in 13 categories. General usability issues were related to the following categories: guidance, workload, significance of codes, explicit control, adaptability, and error handling. Specific (medication-alerting functions) usability issues were related to redundancy / irrelevance of alerts, content, appearance, and alerting features.

As regards the evaluation methods and techniques, in the study of Marcili et. al [14] only two studies are using user testing and only three are using the heuristic evaluation. Most of the studies are using interview, observation, questionnaire, and focus group. Eight studies out of 26 are using only one method. The survey of Klaassen et al. [12] also mention that questionnaires and interviews are the mostly used evaluation methods in this area.

Georgsson et al. [6] used a modified heuristic evaluation method to assess the usability of a mobile application for diabetes self-management support. The method is user-oriented includes dual expertise (healthcare professionals and usability experts), relevant scenarios and user tasks, and in-depth (frequency, impact, and (persistence) severity rating.

Bernhard et al. [3] analyzed the requirements of diabetics and health care professionals as regards the functionality and usability of online centers. According to their study, the main usability requirements are: structured information according to the diagnostic or therapeutic recommendations, intuitive design and navigation based on the user's workflow, ergonomic presentation of the information, possibilities to adapt the character height and the information density, dictionary of medical terms, and means to support the understanding of the information.

In a previous work, an online center for active aging has been evaluated for usability [9]. The evaluation results revealed several important usability problems that were related to user guidance, navigation, compatibility with the user, task guidance and support.

USABILITY EVALUATION

Method

In this study, a task-oriented usability inspection method has been used. Five experts tested the applications with the purpose of anticipating the difficulties a real user might encounter when using the application.

Three evaluation tasks have been tested that are presented in Table 1. The evaluation has been performed in two steps:

- Individual evaluation: each evaluator tested the application independently.
- Collaborative consolidation: agreeing on the list of unique usability problems, agreeing on the severity rate, and finalizing the description of each usability problem.

The similar usability problems were integrated following the "similar changes" technique [7].

Table 1. Evaluation tasks

No.	Task
1	Create a user account on the platform
2	Finding general information and news as regards the diabetes type 2
3	Finding a blood glucose monitoring device

The usability problems are detected and rated for severity by following a task-based approach. Then each usability problem is explained and documented by using the set of 14 heuristics presented in Table 2, as well as more detailed usability guidelines [19].

Table 2. Usability heuristics

User guidance	
1	Prompting
2	Feedback
3	Information architecture
4	Grouping / distinction
User effort	
5	Consistency
6	Cognitive workload
7	Minimal actions
User control and freedom	
8	Explicit user actions
9	User control
10	Flexibility
User support	
11	Compatibility with the user
12	Task guidance and support
13	Error management
14	Help and documentation

The following information has been recorded for each problem: context and location, anticipated difficulties, cause, suggestions for improvement, usability principle (heuristic) violated, and severity.

The reliability of results has been assessed with two indicators: the average detection rate and the average agreement between any two evaluators.

The web-based applications

Three web-based applications that provide online support for diabetics, including facilities for the self-management of medication and diet: ACCU-CHEK, CompletLife, and CGM Diabet. Each application enables the creation of a user account and provides various facilities for the self-management of the diabetes.

Evaluation results

ACCU-CHEK

The number of problems detected by each evaluator varied between 4 and 17. The collaborative consolidation (eliminating the duplicates, the false problems, and agreeing on the severity) resulted in a unique list of 18 problems (11 moderate and 7 minor). The detection rate varied between 22.2% and 50% with and mean of 40%.

Most of the important usability problems were related to user guidance (4), then to user effort (3), and to the user control & freedom (3).

CompletLife

The number of usability problems reported by each evaluator varied between 7 and 14. The collaborative consolidation resulted in a total of 18 usability problems, out of which 1 major and 9 moderates. The average detection rate was 34%.

The major usability problem was the impossibility to find information about the monitoring device. Other important usability problems are related to user effort (3), user guidance (2), user control (2), and user support (2).

CGM Diabet

The number of usability problems reported by each evaluator varied between 3 and 15. After the collaborative consolidation, a list of 25 unique usability problems resulted (11 moderate and 14 minor). The average detection rate was 34.4%. Most of the important usability problems are related to user effort (6) and user guidance (4)

Synthesis of results and discussion

Overall, a total number of 61 usability problems have been identified, as shown in Table 2.

Table 3. Usability problems per task and severity

Task / UP	Total	Major	Moderate	Minor
1	25	0	9	16
2	19	0	12	7
3	17	1	10	6
Total	**61**	**1**	**31**	**29**

The number of important usability problem is pretty large for only three websites. Some typical usability problems have been found that are occurring in all these case studies:

- A lot of redundancy in the content and poorly organized dictionaries of terms, which is confusing the user and makes it difficult to find the information needed.

- One website does not provide a search engine. The other two websites have poor search engines that do not return relevant results.

- Commercial rather than patient-centered design approach, since each website is promoting diabetes-specific medical devices.

- Large banners and too much advertising space on the screen thus increasing the information density and, consequently, the cognitive workload.

- Lack of a help menu that could provide general guidance and support for specific requirements.

- No accessibility options, such as changing the font size, except from the browser settings. Unexperienced users may need help at least for using the browser and operating system accessibility options. Moreover, one website has two search text boxes that are confusing the user.

- Lack of information about the last update as well as old information, dating from 4-5 years ago, thus giving the feeling that the website doesn't provide any news.

Most of the usability problems found are related to the user guidance (24, out of which 10 moderate problems) and user effort (17, out of which 12 moderate problems). User guidance problems are mainly related to prompting and information architecture. It is difficult for the user to find the desired information since the menus are poorly structured.

The distribution of usability problems per ergonomic criteria is presented in Table 4. Most of the important user guidance problems were related to prompting (3) and information architecture (7). As regards the user effort, 5 usability problems were related to cognitive workload and 7 to minimal actions.

Table 4. Usability problems per ergonomic criteria

Criteria / UP	Total	major	moderate	minor
Guidance	24	0	10	14
Effort	17	0	12	5
Control	5	0	5	0
Support	15	1	4	10
Total	**61**	**1**	**31**	**29**

The evaluation results are similar with the results of other studies that found out that the poor user guidance and lack of user-oriented content are accounting for most of the usability problems [13, 14]. For example, in the review of Marcili et al. [14], the general usability problems are mainly related to user guidance (16 issues) and workload (24 issues).

CONCLUSION

Overall, these three platforms for the diabetes care are far from being usable. The task-based inspection revealed a

clear mismatch between the user's workflow and the website design.

The general impression is that these platforms have been developed and launched mainly to promote specific medical devices rather than serving the patients' needs. The fact that finding a blood glucose monitoring device was a difficult task with many usability problems reveals a bad practice in web development: lack of any usability evaluation prior to publish the web site.

Poor user guidance, especially prompting, seems to be a chronical disease of e-health systems development. Given the fact that diabetes is more frequent among middle aged and old people, which are less skilled in using the computer technology, the lack of user guidance is a severe barrier in the e-health adoption.

In order to improve usability, a user-centered design with a focus on user's tasks is needed. A task-based design approach is the only way to ensure a reasonable fit between the users' needs and the application. This approach is more critical in the case of the online medical centers aiming to support people in the self-management of chronical diseases.

In the near future, two research directions are envisaged: usability evaluation of mobile applications for the diabetes care and the elaboration of a detailed set of usability guidelines for the prevention of the most frequent usability issues.

Acknowledgement

REFERENCES

1. Arnhold M., Quade M., Kirch W. (2014). Mobile applications for diabetics: a systematic review and expert-based usability evaluation considering the special requirements of diabetes patients age 50 years or older. *Journal of medical Internet research*, 16(4), e104.
2. Bastien A. & Scapin D.L. (1993) *Ergonomic criteria for the evaluation of human-computer interfaces*. Technical report No. 156, INRIA, Roquencourt, France.
3. Bernhard G., Mahler C., Seidling H. M., Stützle M., Ose D., Baudendistel I., Wensing M., Szecsenyi J. (2018). Developing a Shared Patient-Centered, Web-Based Medication Platform for Type 2 Diabetes Patients and Their Health Care Providers: Qualitative Study on User Requirements. *Journal of Medical Internet Research*, *20*(3): e105.
4. Brown III W, Yen P-Y, Rojas M, Schnall R (2013) Assessment of the Health IT Usability Evaluation Model (Health-ITUEM) for evaluating mobile health (mHealth) technology. *Journal of Biomedical Informatics* 46, 1080-1087.
5. Cockton G. Lavery D. Woolrych A. (2003). Inspection-based evaluation, Jacko, J.A., Sears, A. (Eds.), *The Human-Computer Interaction Handbook*. LEA, 273-292

6. Georgsson M., Staggers N., Weir, C. (2016). A modified user-oriented heuristic evaluation of a mobile health system for diabetes self-management support. *Computers, Informatics, Nursing*, *34*(2), 77-84.
7. Hornbaek K. & Frokjaer E. (2008). Comparison of techniques for matching of usability problem descriptions. *Interacting with Computers 20*, 505-514.
8. Hussain A, Mkpojiogu E, Hussain Z (2015) Usability evaluation of a web-based health awareness portal on smartphone devices using ISO 9241-11 model. *Jurnal Teknologi* 77:4, 1-5.
9. Ianculescu M., Bica. O. , Iordache D.D, Pribeanu C. (2017) A case study of usability evaluation: the Center for Active Ageing website. Mihaescu , M.C., Forbrig, P. (eds.) *Proceedings of RoCHI 2017 International conference*, Craiova, 11-12 September, 61-64.
10. ISO 9241-11 (1998) *Ergonomic requirements for office work with visual display terminals* (VDTs) - Part 11 Guidance on usability.
11. Jong M., Lentz L. (2006) Scenario evaluation of municipal Web sites: Development and use of an expert-focused evaluation tool. *Government Information Quarterly 23*, 191-206.
12. Klaassen B., van Beijnum B.J.F., Hermens H.J. (2016) Usability in telemedicine system – A literature survey. *International Journal of Medical Informatics* 93, 57-69.
13. Lyles C. R., Sarkar, U., & Osborn, C. Y. (2014). Getting a technology-based diabetes intervention ready for prime time: a review of usability testing studies. *Current diabetes reports*, *14*(10), 534.
14. Marcili R, Ammenwerth E, Vasseur F, Roehrer E, Beuscart-Zephir M-C (2015) Usability flaws of medication-related alerting functions: A systematic qualitative review. *Journal of Biomedical Informatics* 55, 260-271.
15. Nielsen, J., and Molich, R. (1990). Heuristic evaluation of user interfaces, *Proceedings of ACM CHI'90*, 249-256.
16. Nielsen J. (1993). *Usability Engineering*. Academic Press, New York.
17. Pipper AM, Campbell R, Hollan J (2010) Exploring the Accessibility and Appeal of Surface Computing for Older Adult Health Care Support. *Proceedings of CHI 2010*, ACM, 907-916.
18. Pribeanu C., Marinescu R.D., Iordache D.D., Gheorghe-Moisii, M. (2010). Exploring the usability of municipal websites: A comparison based on expert evaluation results from four case studies, *Informatica Economică*, 14(4), 87-96.
19. Pribeanu C (2017) A revised set of usability heuristics for the evaluation of interactive systems *Informatica Economica 21(3)*, 31-38.
20. Sears A. (1997). Heuristic walkthroughs: Finding the problems without the noise. *International Journal of Human-Computer Interaction, 9(3)*, 213-234.
21. Theofanos M. & Quesenbery W., 2005. Towards the Design of Effective Formative Test Reports. In *Journal of Usability Studies 1(1)*, 27-45.