Revista Romana de Interactiune Om-Calculator 11 (3) 2018, 231-240

Evaluating the usability of three mobile-based applications for diabetes care

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Abstract. In the last years, there is a growing interest in the usability of software applications for medical care. 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 an empirical study of usability evaluation of three mobile-based applications for diabetes care and a comparative analysis of the identified usability problems. The evaluation results revealed several usability problems that are mainly related to the user guidance, user support and user effort.

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

1. Introduction

Nowadays, the popularity of e-Health software applications on mobile devices is on the rise. Mobile devices have become part of everyday routine among the users of medical care applications. Smartphones are the most popular mobile devices, worldwide statistics showing that one in every five persons possesses a smartphone. At the same time a significant number of online medical centers offer information and support for self-management of medication.

- Smartphones have some limitations when using their interface due to the specific characteristics of mobile devices such as low display resolution, small screen sizes and navigation difficulties. Due to these inherent limitations and the fact that some mobile applications lack robustness, flexibility, and remain difficult to use, there is a growing interest in the usability evaluation of these applications (Alagoz, 2013; Bernhard et al., 2018; Cockton, 2003; Hornbaek, 2008; Klaassen et al., 2016; Nielsen, 1993).

- The systematic adoption of usability engineering in the development of health systems can minimize the number of usage errors that can lead to wrong results to the detriment of patients (Bartoo & Bogucki, 2013). However, there are few evaluation studies targeting usability as the main concern and following a usability evaluation method that uncovers usability problems, such as user testing or usability inspection.
- This paper aims to present an empirical study of usability evaluation of three mobile-based applications for diabetes care. A task-based usability inspection has been used for this purpose. The smartphone evaluation of the three applications follows the evaluation made on desktop systems. For the description 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 next section presents some related work in the area of usability evaluation of the online medical centers. In section 3, the empirical study is presented, and the results are discussed. The paper ends with conclusions and future work.

2. Related work

Usability is an important issue for e-Health systems, as it is one of the factors that contributes most to their success (Hussain et al., 2015). If we do not take into account the degree of use, mHealth (mobile health applications) may have negative consequences, such as increasing medical errors and communicating issues between health care providers (Yen et al., 2014). According to the ISO standard 9241-11 (ISO 9241-11, 1998), usability can be defined 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 (Sears, 1997).

- Usability evaluation aims to identify usability problems, help the developers fix the problems and, this way, improve the usability of the interactive system. A usability problem has been defined by Nielsen (1993) as any aspect of the user interface which might create difficulties for the user.

- In the last years, several studies have been carried out that report on the functionality and usability evaluation of the software applications for diabetics.
- Baig et al. (2015) believe that there are several factors that discourage mHealth adaptation by medical professionals. These factors include: the understanding of advanced technology, the degree of use (size, weight and other basic characteristics), medical implementation and lack of clinical adaptation for individual needs (Baig et al., 2015).
- Demidowich et al. (2012) investigated 42 Android applications for diabetes management. The study concluded that few applications provided a method of self-management of diabetes.
- Marcili et al. (2015) conducted a review targeting the usability of medication-alerting functions. 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. Regarding the evaluation methods and techniques, only two studies used user testing and only three used the heuristic evaluation. Most of the studies used interview, observation, questionnaire, and focus group. Eight studies out of 26 used only one method. The survey of Klaassen et al. (2016) also mentions that questionnaires and interviews are the most used evaluation methods in this area.
- Heuristic evaluation method has been used in the study of Georgsson et al. (2016) in order to assess the usability of a mobile application for diabetes self-management support. The method is user-oriented and includes dual expertise (healthcare professionals and usability experts), relevant scenarios and user tasks, and in-depth (frequency, impact, and persistence) severity rating.
- Ianculescu et al. (2017) evaluated the usability of an online center for active aging. The evaluation results revealed several important

usability problems that were related to user guidance, navigation, compatibility with the user, task guidance and support.

- Bernhard et al. (2018) 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.

3. Empirical study

3.1 Method and samples

There are a lot of usability inspections, but the most widespread is the heuristic evaluation proposed by Nielsen & Molich (2015). 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 task goal (Brown et al., 2013; Cockton et al., 2003; ISO 9241-11, 1998). 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. Another task-based inspection method has been proposed by Pribeanu (2010). In this method, the usability problems are explained and documented by using an extended set of usability heuristics that integrates the heuristics of Nielsen & Molich (1990) with the ergonomic criteria of Bastien & Scapin (1993). Recently, the heuristics have been revised and grouped under four ergonomic principles: user guidance, user effort, user control and freedom, and user support (Pribeanu et al., 2017).

- A task-oriented usability inspection method has been used in this study. Three experts tested the applications in order to identify the usability problems that a real user might encounter when using them. 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 solution), 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 out in the early stages of the development process, being less expensive but more subjective (they depend on the evaluator's expertise). In this case, the usability problems are anticipated (not real) (Brown, 2013).
- 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.
- In this study we used the same evaluation tasks like in Gheorghe-Moisii et al. (2018), testing the same applications, but in a mobile-based configuration. The evaluation tasks are presented in Table 1.
- The evaluation process 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 (Georgsson, Staggers, Weir, 2016).
- Table 1. Evaluation tasks

No.	Task
1	Creating an user account on the platform
2	Finding general information and news regarding the type 2 diabetes
3	Finding a blood glucose monitoring device

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- We used a task-based approach in order to detect and rate the severity of usability problems. Each usability problem was explained and documented by using the set of 14 heuristics presented in Table 2, as well as more detailed usability guidelines (Pribeanu et al., 2017).
- 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

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- For each problem, the following information has been recorded: 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.

3.2 The mobile-based applications

The object of the evaluation was represented by three mobile-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 an user account and provides various facilities for the self-management of the diabetes.

Evaluation results

In the case of ACCU-CHEK application, the number of problems detected by each evaluator varied between 5 and 14. The collaborative consolidation (eliminating the duplicates, the false problems, and agreeing on the severity) resulted in a unique list of 16 problems (9 moderate and 7 minor). The detection rate varied between 19.2% and 53% with a mean of 40%. Most of the important usability problems were related to user effort (4), user guidance (3) and user control & freedom (3).

- Referring to CompletLife, the number of usability problems reported by each evaluator varied between 6 and 15. The collaborative consolidation resulted in a total of 17 usability problems, out of which 1 major and 9 moderate. The average detection rate was 37%. One major usability problem was the impossibility to find information about the monitoring device. Other important usability problems were related to user support (3), user guidance (2), user control (2), and user effort (2).
- Regarding CGM Diabet, the number of usability problems reported by each evaluator varied between 7 and 18. After the collaborative consolidation, a list of 20 unique usability problems resulted (8 moderate and 12 minor). The average detection rate was 32.7%. Most of the important usability problems are related to user guidance (6) and user effort (4).
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Discussion

A total number of 53 usability problems have been identified, as shown in Table 3.

- Table 3. Usability problems per task and severity

Task / UP	Total	Major	Moderate	Minor
1	22	0	8	14
2	16	0	10	6
3	15	1	9	5
Total	**53**	**1**	**27**	**25**

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- As it can be seen, the number of usability issues identified by the three evaluators is quite big. Based on the analysis of the results,

several typical problems for each of the three evaluated applications were identified:

- In both online and mobile use, the presence of some large banners and too much advertising space on the screen is noticed, thus increasing the information density and, consequently, the cognitive workload;
- The lack of a help menu providing general guidance and support for the users of the three applications;
- Most pages are crowded and poorly organized, which is confusing the user and makes it difficult to find the information needed;
- All three diabetes care applications have poor search engines that do not return relevant results;
- The lack of accessibility options, such as changing the font size. Unexperienced users may need help at least for using the browser and the operating system accessibility options.
- Just as in the web configuration of these applications, most of the usability problems found are related to the user guidance (19, out of which 8 moderate problems) and user effort (15, out of which 11 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.
- In Table 4, the distribution of usability problems per ergonomic criteria is presented. Most of the important user guidance problems were related to prompting (5) and information architecture (3). As regards the user effort, 4 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
User guidance	19	0	8	11
User effort	15	0	11	4
User support	14	1	3	10
User control	5	0	5	0
Total	**53**	**1**	**27**	**25**

4. Conclusion

Overall, the evaluation results of mobile applications are quite similar to the evaluation results of the web-based applications. Also, 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 (Klaassen et al., 2016).

- In conclusion, the task-based inspection revealed a number of usability problems, especially at the level of user guidance and control, all three platforms for the diabetes care being far from usable.
- Like in the web-based evaluation, 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 lack of user guidance, especially prompting, user effort and user support seems to be the biggest problems of e-health systems.
- In order to improve usability of the platforms for the diabetes care, a task-based design approach can ensure a reasonable fit between the users' needs and the application (Gheorghe-Moisii et al., 2018). This approach is more critical in the case of the online medical centers aiming to support people in the self-management of chronical diseases.

Acknowledgement

- This work was supported by the Romanian grant financed by ANCS under RESINFO-TD, PN 301 / 2018.

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