Improved Patient Engagement in Self-management of Health, a Key to Sustainable Preventative Healthcare Systems

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Abstract. The use of mobile health together with the Internet of Things (IoT) technology and wireless networks have the potential of reshaping the healthcare systems towards the patient-centred and preventative ones. Better empowered patients which are familiar with smart technology represent a viable way for raising the quality of the self-management of health. Usability is a key factor for a successful acceptance of mHealth solutions. This paper presents the results of the heuristic evaluation of two mHealth apps that support self-healthcare revealed several important usability problems which have to be fixed in the further versions.

Keywords: mHealth · IoT · Patient engagement · Personalized healthcare
Usability inspection · Heuristic evaluation

1 Introduction

Mobile technology in medical care (mHealth) has grown throughout the world over the last few years. This technology changes the way healthcare is provided shifting it towards a patient-centred approach which means that the "care that is respectful of and responsive to individual patient preferences, needs, and values and [ensures] that patient values guide all clinical decisions" [1]. mHealth supports a better engagement of the patients and health professionals aiming to ensure preventive actions and healthier life styles, and to improve health outcomes and health system efficiency.

The concept of self-management of patients is associated with a better empowerment of them and an improved responsibility in taking the most appropriate choices regarding a personal management of the disease.

In a digitalized healthcare system, wearable and in-home sensors collect health data, facilitate analysing and finding insights in the huge amount of stored data and provide real-time actions of healthcare providers.

For a broader acceptance of mHealth usability evaluation has to be performed even from the development process for meeting the patients' demands and necessities.

This paper presents two case studies, TactioHealth app and iMHere app. These are mHealth apps that provide useful information for supporting people in self-care

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activities. The results of the usability inspection of both of them using heuristic evaluation are described.

2 The Potential of mHealth to Remodel the Self-management of Health Processes

The worldwide current healthcare systems aim to provide complex, high quality, cost efficient, accessible and patient-centred care. New healthcare delivery models based on the latest medical research have emphasized the intensive link between the early identification of a disease and the successful treatment results. Thus, a preventative approach of the healthcare services have lately become an increasing demand, imposing a shift in care from treating a disease to prevent or slow down it.

Preventative healthcare can be classified in primary (avoiding the occurrence of a disease), secondary (controlling a disease from the early stages by minimizing its impacts) and tertiary (identifying the most appropriate management of a chronic disease for raising the quality of life of the patient).

Preventative healthcare systems imply both a proactive and a predictive tackling as specified in [2]: "Proactive care solutions stratify at-risk individuals based on known algorithms and ensure that preventive action is taken to intervene well before the onset of symptoms. Predictive care solutions leverage cutting-edge technologies and sophisticated machine learning data algorithms to predict risk and intervene even further upstream".

Continuous changes at the societal level and the huge technological advances enforce a shift towards a more comprehensive patient empowerment. The tremendous role of information communication technology in the healthcare systems and the broader access to knowledge have sustained the emergence of a new category of patients, digitally active and having quite well established demands and expectations regarding integrated patient-centred healthcare services.

Digitalisation has also facilitated an increased role of the patient in his/her self-health management, with many benefits like: better engagement with healthcare providers, greater confidence, enhanced safety, improved health outcomes, cost and time efficiency. mHealth has proved to be a successful tool for better engaged patients looking for smarter healthcare.

The most appropriate domains for mHealth applications comprise: self-monitoring of health parameters (in conjunction with wearable devices and IoT), remote consultations, emergency management, health data acquisition, storing and processing, comprehensive and limitless access to health knowledge.

According to [3], 36% of respondents believe the use of app-enabled patient portals is the most effective tool in patient engagement.

To get the most out of the mHealth targeting the self-management of health, the most appropriate, familiar and personalised user interface design has a key role in a broader acceptance of these health services, together with a more consistent use of interoperability standards, more pervasive ways to collect, analyse health data in order to transform

it into improved knowledge, and also with better issues of privacy and security in order to increase the confidence of the patient-users.

The continuous emerging of newer mHealth based solutions and technology, the integration of smart devices into everyday life and the increased degree of the patients' acceptance accelerates the reshaping of the healthcare systems.

3 The Internet of Things - Facilitators of for Improving Patient Engagement and Personalized Healthcare

The IoT can provide early detection of abnormal health data and rapid response to medical emergencies, support patients' adherence to often-complex medication regimens, and offer a greater confidence. The emergence of wireless networks in healthcare applications gains momentum by increasing the number of vital signalling sensors and localization tags that can track both medical staff and patient status/location continuously in real time [4].

"IoT is the network of physical objects or "things" embedded with electronic devices, software technologies, sensors and networked connections, which facilitates the collection and exchange of data to benefit from various services" [5]. IoT is a concept reflecting a connected set of anyone, anything, anytime, anyplace, any service, and any network. IoT is a technology for interconnection of uniquely identifiable smart objects and devices within today's internet infrastructure with extended benefits.

With IoT, many medical applications can be generated, such as remote health monitoring, health programs, chronic illness [6].

Wireless health care systems can be used together with IoT systems. These systems include health sensors, smart phone devices and server system for information control and management [5]. The sensors contain input values that they transmit to the server using the smartphone. The server processes the data and informs the patients. These health systems help patients make decisions based on what their application transmits.

The monitoring system is mainly based on two types of sensors: *wearable sensors* that are attached to the patient to measure vital parameters and *in-home sensors* embedded in and around the different parts of the patient's room [7].

IoT allows a variety of health care services where each *service* offers a set of health care solutions. Of the types of IoT-based healthcare services we mention: Ambient Assisted Living (AAL), The Internet of m-Health Things (m-IoT), Adverse Drug Reaction (ADR), Community Healthcare (CH), Children Health Information (CHI), Wearable Device Access (WDA), Semantic Medical Access (SMA), Indirect Emergency Healthcare (IEH), Embedded Gateway Configuration (EGC), Embedded Context Prediction (ECP).

Figure 1 shows the operation of wireless networks used to help patients. It consists of sensors attached to the human body, wireless devices, server system and doctors and hospitals that provide patient services [5].

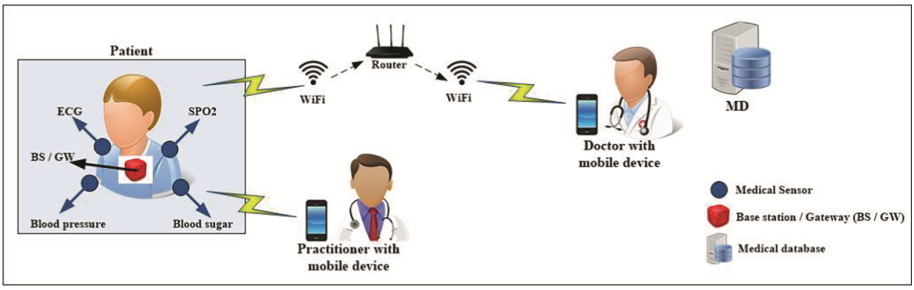

Fig. 1. Wireless sensor networks for healthcare

4 Usability Evaluation of mHealth Apps Supporting Self-care

The ISO 9241-11 standard defines usability as "the extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use" [8]. Poor usability is a major obstacle to health information adoption and a clear cause of medical error [9]. Usability is a key determinant to the adoption and success of mHealth into disease self-management [10].

Usability evaluation aims at finding, documenting, and reporting usability problems for refining the design of the system to address the problems found. Usability evaluation methods are classified in: inspection methods and user testing [11]. *Usability inspection* is done by experts that are testing the user interface with the goal to anticipate usability problems. The most widely used inspection method is the *heuristic evaluation* [12], where an expert reviewer assesses the tested user interface with a set of universally accepted usability principles (heuristics). Table 1 illustrates the 11 principles of the heuristic evaluation for mHealth apps that are in accordance with the 10 principles proposed by Nielsen [13], and the last is from Karat et al. [14].

Table 1. Principles of good interface design (heuristics).

No.	Heuristics
1	Visibility of system status
2	Match between system and the real world
3	User control and freedom
4	Consistency and standards
5	Error prevention
6	Recognition rather than recall
7	Flexibility and efficiency of use
8	Aesthetic and minimalist design
9	Help users recognize, diagnose, and recover from errors
10	Help and documentation
11	Intuitive visual layout

4.1 mHealth Apps: Case Studies

The objective of the presented case studies was to evaluate the usability of two mHealth apps that enhance the quality of life by empowering the patient with self-care possibilities:

1. *TactioHealth app* consists in mobile proactive applications suited for helping people to manage a healthy lifestyle. Tactio software apps provides a better health management without requiring medical expertise. There are apps dealing with Diabetes (see Fig. 2), Obesity, Hypertension, Atherosclerosis, COPD, CHF, and Pregnancy. Patients are empowered to manage a wide range of health data from simple manual logging to self-tracking apps connected to medical devices. Reference ranges are provided by incorporated science-based rules and can be used on every data: weight, steps, nutrition, activity, sleep, mood, blood pressure, pulse, glucose, cholesterol, temperature and oximetry [15].

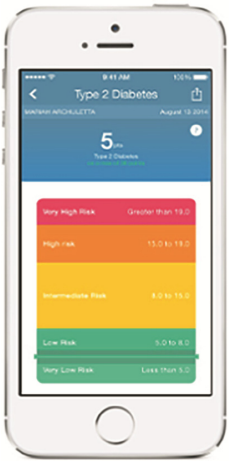

Fig. 2. Tactio Type 2diabetes mHealth Apps

2. *iMHere (Internet Mobile Health and Rehabilitation)* is a mHealth system developed to support self-care and adherence to self-care regimens for individuals with spina bifida and other complex conditions who are vulnerable to secondary complications [16]. The system allows clinicians to monitor a patient's condition and send a treatment plan for each patient to a smartphone designed to empower patients to do preventive self-care and adapted to user's disabilities. The five apps that constitute the iMHere support preventive self-care for managing medications (MyMeds), neurogenic bladder (TeleCath) and bowel (BMQs), skin breakdown (SkinCare), and mood (Mood) as presented in Fig. 3. It is possible to generate self-created reminders with customized alarm tones and messages prompted individuals to perform tasks related to self-care at home.

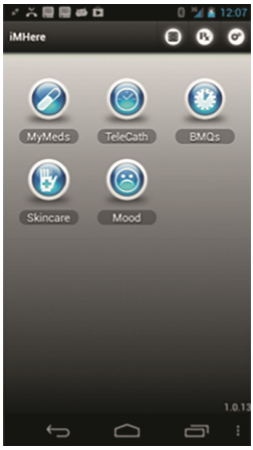

Fig. 3. iMHere mHealth App - Home screen for suite of apps

4.2 Results of Heuristic Evaluation of mHealth Apps

In order to address any issues concerning the use of mHealth apps inspected in the two case studies, a group of users (acting as patients) was introduced to the usability study. Previous studies from HCI literature found that 80% of usability problems can be detected with only 5 subjects [17, 18], and almost all of high-severity usability problems with only 3 subjects [17]. In this study, 5 evaluators (3 women and 2 men) specialised in: web design, medical care, healthy lifestyle, psychologist, caregiver tested the selected mHealth apps independently and reported the usability problems found for each of the six main themes emerged from usability literature [19]: Presentation of health information; Aesthetic and minimalist design; Flexibility and efficiency of data input; Task feedback; Intuitive design; and App stability. None of the evaluators has severe intellectual disability and any problem in vision, hearing, speech, or hand moving which would affect operation of a smartphone device. All subjects were smartphone users prior to be included in the study. Two evaluators are usability experts and three are patients.

Before starting the evaluation, each evaluator received the evaluation themes, the set of usability heuristics, and two papers with examples of usability inspection. The usability inspection has been done independently by each expert using his/her own smartphone during 90 min.

According to the potential effect on the theme, the severity of the detected usability problems has been assessed as severe, moderate and minor.

Each evaluator detected between 5 and 9 usability problems and specified each of them on an Excel table. After removing the false ones and analysing each problem in order to agree on the severity, 13 usability problems in TactioHealth app and 12 in iMHere app resulted as important. The usability evaluation results are presented in Table 2.

Table 2. Usability problems per task and severity

Theme	TactioHealth app				iMHere app			
	Total	Severe	Moderate	Minor	Total	Severe	Moderate	Minor
1	2	0	1	1	6	1	3	2
2	2	0	2	0	1	0	1	0
3	3	1	2	0	1	0	1	0
4	2	0	2	0	1	0	1	0
5	3	0	1	2	2	0	1	1
6	1	0	1	0	1	0	1	0
Total	13	1	9	3	12	1	8	3

The two severe problems are related to the big quantity of input data in TactioHealth app and to the small dimension of some activity buttons at the top of the screen diminishing users' access capabilities in iMHere app.

Most of the moderate problems are related to the findings presented in Table 3.

Table 3. Usability results for the two case studies (moderate severity)

No.	Theme	Key usability problems in TactioHealth app	Key usability problems in iMHere app
1	Presentation of health information	– Too small dimension of graphs for seeing trends over time	– Light text colour such as white or yellow on a light background (e.g., grey) causing reading difficulties; – Narrow width of the scrollbar leading to under-completion of the data – Difficulties in understanding the meanings of certain words (e.g. alias)
2	Aesthetic and minimalist design	– Overcrowded screens – Obstructive decorative elements competing with relevant content	– Overcrowded screens
3	Flexibility and efficiency	– Lack of flexibility in entering data	– Not patient centred design leading to not appropriated remainders, and scheduling – Errors in tasks procedures by not using of in-app directional notes
4	Task feedback	– Too much input data requested by apps and no feedback provided – Lack of feedback to state the completion of an action	– Non appropriate use of words in dialog with the users
5	Intuitive design	– Difficulties in understanding how to use an app	– Lack of different colours for different apps
6	App stability	– Occasional apps breakdowns	– Certain problems for sending data if 4G signal is unstable

5 Conclusion

Inside the healthcare systems, mHealth has proved to bring value and an increased quality both from the point of view of healthcare services and of a more comprehensive and involved self-health management performed by the patients. A preventative approach of lifestyle and health supported by smart technology and patient-centred solutions have transformed the passive patients into active engaged actors. Despite the tremendous development of smart health technology, a greater importance has to be put on designing more familiar and personalised mHealth solutions for increasing their degree of integration in patients' everyday life. Usability evaluation of mHealth solutions can reveal the issues that might restrain their acceptance, use and the positive impact on self-management of patients' health as it has demonstrated inside this paper.

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