Remote Usability Study on mHealth app VirTelMed in a South African Setting

Guillermo Martínez Pérez
Fac. Health Sciences
University of Zaragoza
C/Domingo Miral s/n, Zaragoza (Spain)

Daniel Massaguer Pla, PhD.
Academic Collaborator
Msc Telemedicine
Open University of Catalunya

ABSTRACT
mHealth initiatives are becoming a growing solution for healthcare provision in developing countries. With the purpose of helping people from underserved areas to access physicians, the University of California Irvine has designed the mobile application VirTelMed. The objective of the study was to implement a usability study of VirTelMed in South Africa, with a focus in its design, usefulness and intuitiveness. The study is based on observing how the respondents attempt to perform a series of tasks, complemented with a semi-structured interview. Namely, 16 persons were asked to test VirTelMed. In average, the respondents expressed satisfaction with its intuitiveness, usefulness and design. Remote usability studies that use methods such as participant observation and interviews allow software developers to test mHealth applications in diverse contexts, and obtain useful contributions. Participatory tools have to be featured to allow the testers to contribute remotely to the design of the applications.

General Terms
Mobile health, Software Testing, Mobile Applications.

Keywords
South Africa, mHealth, User Study, Qualitative, Ethnography.

1. INTRODUCTION
The phenomenon of mobile phone use is increasing worldwide, with more than 5.9 billion subscribers –an 87% global penetration, 79% in the developing world [1].

With regards to Internet, 35% of the world population is connected. Of those, 62% in 2011 live in developing countries; while in 2006 this figure represented only 44% [1].

In South Africa, where this study was carried out, the rate of mobile penetration is 101 mobile subscribers per 100 population in 2010 [2]. With 50.460.000 inhabitants, South Africa is considered one of the most emerging countries, with a Gross Domestic Product per capita of 9´333$, ranking the 123 of 182 countries in the United Nations Development Program Human Development Index [3].

Mobile phones are becoming a widely acceptable and efficient tool to provide healthcare services in underserved areas [4]. Because mobile phones are the most successful computing platform in emerging markets, for the purpose of healthcare provision, devices with 3G wireless connectivity can be far more compelling to users than desktop computers [5]. The possibility to have Personal Health Information (PHI) exchanged between patients and physicians is emerging as a low-cost, instantaneous and ubiquitous medium that improved patients´ health, healthcare providers performance, and public health systems indicators [6,7,8][1].

mHealth is defined as the use of *"portable electronic devices for data communication over a cellular or other wireless network of base stations to provide health information"* [9]. Because of its contribution to remove barriers to healthcare delivery, mHealth initiatives can be designed for a wide variety of settings, including scenarios such as displacement of civil populations, or natural or man-made catastrophes [7]. mHealth can be used for the traditional services of eHealth; teleconsultation, telemonitoring, eLearning, eReceipt, Electronic Health Records (EHR), and decision aid tools [2,4].

The functionalities of mHealth are miscellaneous. Cell phones on the patient end are used to generate a flow of information for improving illness monitoring, medication compliance, promoting smoking cessation, reducing missed clinic visits, or transmitting images for diagnostic purposes [10].

In developing countries mHealth offers an opportunity to strengthen health systems and combat a wide spectrum of chronic and infectious diseases. mHealth can help achieving the 4th, 5th and 6th Millennium Development Goals of reducing child and maternal mortality and halt the spread of HIV/AIDS, malaria and other diseases [11,12].

With mHealth, information and expertise are broadly available to health practitioners and patients, and diagnostic tools delivered at the point of care by means of using a mobile phone are improving the way in which people are receiving healthcare [4,6,13].

1.1 VirTelMed
The Institute for Software Research (ISR) of the University of California Irvine (UCI) has designed VirTelMed as an open source mobile application to enable medical virtual volunteering [13,14,15]. A system where both health practitioners could assist those without access to medical care, and patients could participate by communicating with healthcare providers, reporting changes in their health status, and by building their own health communication tools.

[1] Personal Health Information (PHI): Identifiers and information on the patients´health status [25].

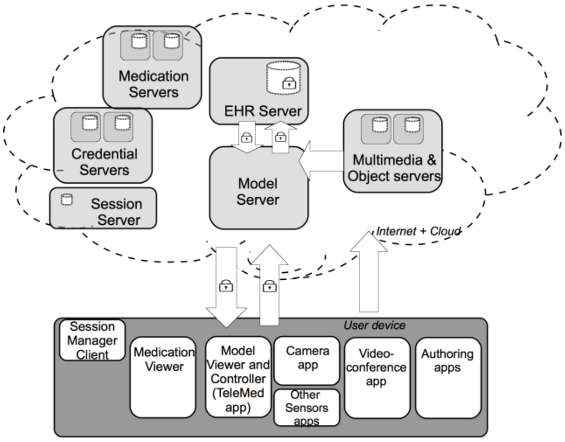

Figure 1. Architecture of VirTelMed

Based on an ethnographic and user study in USA and Nicaragua, the functional requirements of the system were elicited, and the architecture of the application was designed (Fig. 1) [14,15].

VirTelMed is composed of back-end servers running on the Internet and front-end clients running on the users´ devices (mobile phone, desktop, laptop, smartphone or PDAs). PHI is secured by the use of encryption and authentication mechanisms, and it is stored on the Internet as it is safer than on a cell-phone due to phone sharing and surrogate use [10,14-15].

VirTelMed has been designed for WebKit-based browsers (Safari, Chrome or Firefox). It can be accessed in Blackberry, iPhone, Window and Android mobiles. It can be browsed in Firefox in a Windows operating computer, and in Google Chrome in a Macintosh computer.

Its interface is implemented as a set of menus styled with Cascade Style Sheets (CSS) mimicking the appearance of an iPhone application (640x960 pixels appearance).

The interface has three work areas (Fig. 2):

- On the left area the users connected, and the options to change the patient´s gender, the language, and the anatomical systems can be seen.
- On the center it is placed the avatar that represents the patient.
- On the right it is possible to see a set of menus that allows selecting different types of pain, skin conditions, and other symptoms, as well as sections where to discuss the diagnosis, and access a prescription menu.

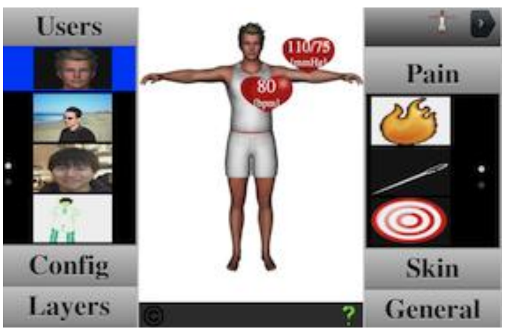

Figure 2. VirTelMed Interface

1.2 Purpose

The main goal was to implement a remote usability study of VirTelMed in South Africa, with a focus in testing the cultural compatibility and acceptability of its interface. Other objectives were:

- To know how the usefulness of VirTelMed is perceived.
- To receive feedback to improve the application functionalities and design.
- To validate a remote usability study design.

1.3 Related work

mHealth is not anew in South Africa. A wide variety of projects have been piloted in the last decade [9,10,16,17,18]. Beyond South Africa, hundreds of mHealth initiatives have been piloted worldwide. A search for experiences of mHealth solutions that have been tested following an ethnographic approach was carried out. Not so many experiences have been found. Some examples:

- In India, Grisedale tested a newton-based data-capture and viewing prototype, which would provide contextual performance support and health education to healthcare workers [19].
- Also in India, Medhi tested visual representations of common symptoms of illness with illiterate people, trying to ascertain which type of representation would be more understandable [20].
- Arsand designed web and mobile phone-based systems to help diabetics to manage their diets after conducting qualitative usability tests in order to understand which aspects of its design their users more appreciated [21].
- Luk carried out fieldwork in nine medical institutions using semi-structured interviews, participant observation and focal group discussions, aiming to detect cultural differences between health practitioners and software developers [22].

Designing and implementing a user study in the target context prior to the deploying of an application is crucial to achieving success, because there are differences in the way experimenters and users think and represent health concepts [19,23]. Not understanding and taking into account these differences can lead to the total fail of an mHealth project [24].

2. METHODS

2.1 Study framework

Ethnography is an observational and non-interventionist research technique identified as a useful tool to software design because it observes and analyses the social context in which the applications are to be used by the target population [25]. Ethnography being the framework, and based in the experiences found in the literary review, participant observation and a semi-structured questionnaire were the tools chosen to implement this remote user study. Remote meaning testing the application in the natural context where the target users would make use of it by means of the ethnographic tools aforementioned, browsing the application in a device with Internet connectivity, and allowing the respondents to provide input using the participatory tools VirTelMed offers (open source, source code available, and option to upload their own generated audio-visual representations or A-V Atoms).

The questionnaire was validated in Nicaragua in a study carried out by the VirTelMed developers [14,15]. It was tested prior to implementation to ensure that the questions were adapted to the cultural characteristics of the study site [26].

2.2 Study site

The setting of the study was Stellenbosch, a city of 58.000 inhabitants, in Western Cape Region, South Africa [26].

2.3 Study sample

The only inclusion criteria were that the respondents aged above 18 years and that they were South African citizens. No identifiers were requested, but other socio-demographic information was asked, such as their gender, age, ethnic group, education, mother tongue, illiteracy and/or innumeracy, and their monthly income.

The sample was selected using snowball-sampling techniques [27,28]. All tests and interviews were conducted face-to-face in their homes.

2.4 Study protocol

The Ethics Committee of the Open University of Catalunya approved the study protocol. The protocol was designed in collaboration with the ISR of UCI. The researchers went through the following steps during the study:

- Explanation of VirTelMed application and study protocol. Informed consent obtained.
- Watching a tutorial video on VirTelMed uploaded in YouTube [14].
- Allowing the respondent to get familiar with the application while performing a set of tasks in a labtop with VirTelMed browsed in Google Chrome.
- Assisting the subject in filling the online questionnaire.

3. RESULTS

The study was implemented in May 2012. Sixteen respondents were included in the study. No more respondents were recruited since data saturation was achieved [27,29]. All the respondents were South African citizens aged above 18 years (Table 1). Ten were male and six were female. With regards to their age, one female was 40 years old. The others ranged between 20 and 29 years. With regards to their ethnicity (Table 1), fourteen were Caucasian, one was Coloured and one was Black[2]. Thirteen respondents had graduated studies, one had post-graduate studies, and two of them had finished secondary school. With regards to their monthly incoming, eight of them said they earned less than 5,000 ZAR per month, while six earned between 5,000 and 10,000 ZAR, and one earned between 10,000 and 20,000 ZAR.

The respondents were asked if they had a smartphone and how they would feel if they had to use it to access healthcare services. Fourteen of them had a smartphone for one year while the other two had a low-range cellphone. When asked what operating system they had been using so far, nine persons said they had used Blackberry, while Android had been used by four respondents, and Windows, Symbian and iOs by 1 person each. Those who have a smartphone considered themselves quite familiar with navigating the web (4.43 on a 7 points Likert Scale with a Standard Deviation (SD) of 1,05). In average, they would feel quite comfortable (avg 5.25, SD 1,12) with smartphones being used for healthcare applications. Most respondents would feel quite comfortable (avg 5.62, SD 1,02) with having their PHI being transmitted over the Internet.

Table 1. Age, gender, ethnicity and mother tongue of the participants. (E:English; A:Afrikaans; I:Isi-Xhosa)

AGE	GENDER	White			Coloured			Black			TOTAL
		E	A	I	E	A	I	E	A	I	
15-20	Male	3	1								4
	Female	1	1								2
21-25	Male	3	1								4
	Female		1								2
26-30	Male						1			1	2
	Female	1	1								2
31-40	Male										0
	Female	1									1
SubTotal	Male	6	2				1			1	10
	Female	3	3								6
TOTAL		9	5				1			1	**16**

Eight of the respondents said they go very rarely (1-2 times per year) to the doctor, while three said they go rarely (3-5 times per year) and other three said they go often (6-10 times per year). All the respondents feel quite trusting with their health system (avg 5.5, SD 1,5). However, ten of them explained that they were users of the private health companies. They were also asked to rate the ease in communicating with their doctors, finding this aspect most of them very easy (avg 6.25, SD 0,68). Finally, most of them thought very easy getting an appointment with their doctors (avg 6.25, SD 1,06).

3.1 Tasks

The respondents performed a set of tasks on the VirTelMed interface. Fifteen attempted to perform the tasks. The ones who attempted were asked to rate how they considered they had succeeded in performing the tasks. In average, they considered they had managed to perform correctly all the tasks (Table 2).

3.2 Design, intuitiveness and usefulness

With regards to VirTelMed design, in average, the respondents rated as well designed the use of an avatar of the human body to correspond with the patients´ bodies (avg 6.37, SD 0,88), the display of the users connected (avg 5.87, SD 0,95) and how the interface displays the patients' PHI (avg 6.06, SD 0,99) (Table 3).

The expression of symptoms was in general perceived as useful (avg 5.75, SD 1,00). With regards to future features to be supported, the respondents rated as very important the option to upload images taken from a smartphone (avg 6.37, SD 0,94), to post questions and status updates to notify health professionals via a social networking (avg 6.25, SD 0,93), and a text-to-speech technology for those who have visual/hearing impairment (avg 6.00, SD 1,31).

[2] The Stellenbosch Municipality Integrated Development Population (IDP) distributes the local population in four ethnic groups: White, Coloured, Black and Asians [26]

Table 2. Average rating of how the respondents thought they had performed the exercises (1:Not at all; 2:Partially succeed; 3: Succeed)

How well do you think you managed to…	Mean (1-3) and SD
… place sharp pain in the patient’s left shoulder?	2.75 (0,57)
… select the diet of the patient?	2.75 (0,57)
… place rash in the right leg of the patient?	2.68 (0,60)
… return to English language?	2.68 (0,60)
… change the sex of the patient?	2.68 (0,60)
… place heartburn in the stomach of the patient?	2.62 (0,61)
… change the language of the application?	2.52 (0,62)
… identify the users connected?	2.37 (0,61)
… change the representation of burning pain?	2.06 (0,85)
… to upload a photo of you?	2.06 (0,92)

The respondents rated as very satisfactory the overall usefulness (avg 6.25, SD 0,93), intuitiveness (avg 6.00, SD 1,03) and visibility (avg 6.37, SD 0,80).

3.3 Problems

The most mentioned problem was to find how to change the intensity of pain (4 respondents). Other problems mentioned were the selection of icons and how to place them in the human body avatar (2), scrolling down the menus (1), the titles of the fields being unspecific (1), and changing the language (1).

Regarding missing features, nine respondents said they could not think of any. Three suggested a drop down checklist for the different degrees of pain. Other suggestions were to have a zoom function (1), the possibility to talk directly to the doctor (1), and options to register the patient's age (1), the climate (1) and the degree of discomfort (1).

Regarding the negative features of this technology, two respondents said that the app could not be used in remote areas with poor or no Internet connectivity. Other answers given were that some of the icons might be misinterpreted (1), patients might be misdiagnosed (1), electricity supply was necessary (1), and that the application would be only available for persons with access to a smartphone (1).

Improvements suggested include that the application should be open source (1), incorporate more external factors (such as the household composition) (1), aids for illiterate users (1), more options for types of pain (1), to be operable on a Blackberry (1), and to add a text caption to the icons (1).

3.4 Use of VirTelMed

Fourteen respondents said they would use the application. Eight said they would use it to anything but a life-threatening disease. Four interviewees mentioned mild respiratory infections. Burning pain, muscle pain, unspecified aches and skin problems were mentioned twice. Psychological problems and stomach pain were mentioned once.

3.5 Overall observations

The application being *“user-friendly”* was an impression remarked by seven persons. This was enhanced by the fact that the tutorial video was very effective and helped them to understand quickly how the application functions.

Table 3. Average rating of how the respondents thought the design, intuitiveness and usefulness.

How would you rate...?	Mean (1-7) & SD
The use of an avatar of the human body to correspond with patients' bodies	6.37 (0,88)
Display of users connected	5.87 (0,95)
Display of patients' PHI	6.06 (0,99)
Expression of symptoms	5.75 (1,00)
Ability to upload images taken from a smartphone	6.37 (0,94)
Ability to post questions and status updates to notify health professionals via a social networking	6.25 (0,93)
Text-to-Speech technology for those who have reading/visual impairments	6.00, (1,31)
Overall usefulness	6.25 (0,93)
Overall intuitiveness	6.00 (1,03)
Overall visibility	6.37 (0,80)

“The *program is very intuitive in how it identifies with primitive correlations such as fire and a pin-prick for sharp pain, however the user-interface is slightly clumsy and difficult to operate proficiently, even to me as a technologically competent individual. Making it simpler to operate and navigate would do well for the program in the context of its universal use in* countries *where illiteracy is rife.”*

The application would be useful in remote areas with basic health problems and little to no access to medical facilities according to seven respondents.

“It will help with treatment and diagnosis in areas where medical research and development is lacking or where the knowledge required to treat symptoms is not available.”

It was highly valued that the application could be used in a mobile phone.

“Should a person sustain an injury out in the wilderness or otherwise away from any medical assistance, he/she could recreate the ailment on the app and forward it to the relevant medical professional and receive advice. Especially helpful if the person in question has no first aid experience or training.”

3.6 Participant observation

Despite the respondents claiming they managed to finish all the tasks, when they were testing VirTelMed it was observed that some had problems to scroll down in the menus, placing the symptoms icons on the patient’s body, and finding where to change the language and how to display the different representations of pain. Besides, the rating system regarding different representations of the same concept was confusing for most of the respondents, as it was confusing what the time frame of habits is. For instance, when asked to place types of food by the side of the patient’s representation, three respondents said it was not clear whether what the practitioner would want was what the patient ate the day before, or what the patient regularly consumes. It was also noticed that some had difficulties to identify the symbols that represented burning pain, rash or sharp pain.

4. DISCUSSION

One of the main objectives was to validate the study design. Traditionally, software can be tested in a lab where the respondents are filmed while using it. Because a lab is not the natural environment where the target users would use the application, contextual bias might be introduced. In a different setting, it can also be tested remotely by having the respondents trying the application in their personal devices and then submitting an online survey on their impressions. But, in this second scenario due to the absence of participant observers, comments, problems and behaviors are missed [25,30]. For this usability study, a methodology that lies between the two models of software testing described above was designed. It was preferred to test the application in the second scenario described (in the user´s environment), with a researcher practicing participant observation, in order to take into account all comments, attitudes, worries, problems and behaviors that could be otherwise missed (Fig. 3). Like similar evaluation methodologies, this methodology proved to be an effective approach that provided important feedback on acceptability, user-friendliness, usability and design that can have a bearing on the success of an mHealth application [25]. The main advantage of the methodology is that it provides qualitative and ethnographic data directly obtained from the natural context where the users would use this type of applications.

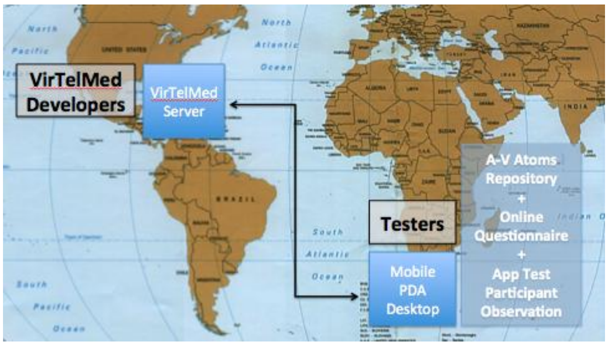

Figure 3. Remote Usability Study Model

Representing different medical concepts visually is indeed a challenging task. When designing a health software, richer information does not mean better understanding for the users, with cartoons doing better than photorealistic representations and voice annotation helping to understand, but bimodal AV information being confusing for illiterate users [23].

Participant observation and the questionnaire provided us some useful information on this issue. Voice and text over the images was an option that some of the respondents suggested in order to make the images more understandable. Besides, it was again clear that, if the representations were not understandable from a cultural point of view, the interface would not be intuitive, no matter whether the representations are drawings, photographs, or videos.

In remote user studies, it can be considered useful that the testers can be asked to contribute to a distributed repository of A-V Atoms. Each atom representing a single concept, users from different cultures can be encouraged to participate in designing the interface by means of a participatory process of creating and uploading graphical representations of medical concepts. The right combination for each medical concept is context-dependent, but, through this process, the software developers will have tools to have the final interface of their products culturally understandable.

4.1 Recommendations

Based in the results obtained, for future remote usability studies, some suggestions can be raised considering the following aspects:

- Promote a participatory approach facilitating means to the users to contribute to a distributed repository of A-V Atoms.
- Allow the app to be open source to permit remote testers to suggest changes in its source code for a better functioning when usability problems had been detected.
- Enhance ethnographic techniques to gain a better understanding of the behavioural and cultural dynamics of the software testers.
- Qualitative studies with semi-open questionnaires can help obtaining more accurate information than qualitative scales that might be difficult to interpret for the participants of the study.

Only with real users in a real context the usability problems will de detected as problems. Some design aspects might not impede a specific user to use an application but might still pose usability problems if they impact other users´ experience. Being access to proper healthcare a universal human right, VirTelMed should be usable by as many users as possible and no user should be precluded to use it because of his/her profile, regardless of how many people meet the same profile [29]. Hence, the decision to change some aspects of VirTelMed, such as some symptoms representations, should not be based in the number of users bothered during the study. Nevertheless, the decision cannot be taken if potential problems have not been identified properly [20].

Some argue that a disadvantage of a method like the one used in this study is that it helps to detect usability problems but it does not provide suggestions on how to solve them [20]. But it was noted that by using research tools such as participant observation and a semi-open questionnaire, the feedback received from the participants offers a lot of ideas to improve the application, make it user-friendlier and adapt it to the target context.

4.2 Privacy and security

While filling the survey, five respondents asked more information on the concept of PHI explaining that they would feel comfortable to use an internet application to share information as far as personal identifiers were not requested. In a context like South Africa, where HIV/AIDS and tuberculosis are highly prevalent [31], it would be wise to develop measures to guarantee the privacy and confidentiality of the patients' data.

4.3 Bias

Some selection and procedure bias might have influenced the results:

- The test was done in a Macintosh laptop. Only one respondent was familiar with this type of operating system.
- The demographics of the respondents do not correspond with the profile expected from the target users of VirTelMed. The respondents were not illiterate or dwellers of underserved areas. Nevertheless most of them said they would use

VirTelMed. But, for future studies, mHealth apps of this sort are better to be tested in one of the shantytowns of Stellenbosch, where most likely users with none or limited access to health practitioners will be found.

- A bias of perception related to the gender of the participants might be considered because most of the respondents were male.
- All the respondents had problems when answering the Likert Scale format questions.

5. CONCLUSION

In this remote usability study the application VirTelMed has been tested, an mHealth project developed with the purpose to help medical volunteers to assist patients living in underserved areas.

In the study an ethnographic approach inspired by previous fieldwork was followed, designing a study protocol that included participant observation, a questionnaire, and testing of the application in a laptop with Internet connectivity.

Sixteen respondents were enrolled in the study and provided feedback on their perceptions of the acceptability, usability, intuitiveness, design and future features to be supported by VirTelMed.

It was observed that some representations of the application could be changed in order to get an interface adapted to the South African context. The respondents missed some functionality that might be introduced, and suggested changes in the representation of the symptoms and food. In average, the overall intuitiveness, usability and design of the application were considered as satisfactory.

The suggestions given can be adopted because VirTelMed is scalable, allows users to upload their own representations to a distributed repository of A-V Atoms, and it is licensed as open source. The authors of this paper consider crucial to have these characteristics in place when implementing remote usability studies.

For future research, it has to be assessed how mHealth projects such as VirTelMed can be used for remote consultation as a cost-effective alternative for managing chronic disease risk factors, infection control, providing health education, preventing emergencies or life-threatening conditions, improving care for patients living in underserved areas, and reducing patient load and expenses in health assistance in national health systems [24].

6. ACKNOWLEDGMENTS

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