A Decision Support System for Medical Mobile Devices Based on Clinical Guidelines for Tuberculosis

Sílvio César Cazella[1,2], Rafael Feyh[2], and Ângela Jornada Ben[1]

[1] Federal University of Health Sciences of Porto Alegre, Rio Grande do Sul
Rua Sarmento Leite 245, 90050-170, Porto Alegre, RS, Brazil
[2] University of Vale do Rio dos Sinos, Centro de Ciências Exatas e Tecnológicas
Av. Unisinos 950, 93022-000, São Leopoldo, RS, Brazil
{silvioc,angelajb}@ufcspa.edu.br, r_pohren@hotmail.com

Abstract. The decision making process conducted by health professionals is strongly linked to the consultations of clinical guidelines, generally available in large text files, making the access to the information very laborious and time consuming. The health area is very fertile for the emergence of solutions based on mobility. Among others, there are solutions that offer to the doctor the access to the right information when and where needed, contributing so that the health services can be performed at anytime and anywhere. This study presents an application for mobile devices where you can get access to the content of clinical guidelines (in this case Tuberculosis' clinical guideline). The prototype was evaluated by medical experts, showing promising results.

Keywords: Mobile Devices, Clinical Guidelines, Android.

1 Introduction

The use of mobile devices is increasingly present in the lives of professionals in various fields. In particular the area of health, because it is a very sensitive area due to their needs and relevance. The application of mobile technology in healthcare will enable their professionals to be more productive and efficient, bringing significant benefits to the staff of Health and their patients.

Mobile applications can connecting patients and providers related to health services, making the patient's history easier monitoring, once the patient has medical follow in his hands. Thus, mobile applications will play an important role in shaping the future of systems of public and private health. The steady increase in the use of mobile devices such as mobile phones, smartphones, tablets, among others, by health professionals has minimized the resistance of the users regarding the use of such applications. Thus, increasingly we find applications available for these devices, which in turn become excellent tools for the working environment of health professionals. In 2013, for the first time in history , smartphone sales surpassed sales of regular mobile phones , reaching , based on data from the first quarter , the mark of 216 million units , representing 51.6 % of total mobile phones and smartphones marketed during this period [7].

C. Ramos et al. (eds.), *Ambient Intelligence - Software and Applications*,
Advances in Intelligent Systems and Computing 291,
DOI: 10.1007/978-3-319-07596-9_24,

According to [3] , the total number of smartphones sold worldwide in the second quarter of 2013 was 236.4 million units , representing an increase of 51.3 % compared to the second quarter of 2012 . The Android operating system maintained its leadership position , achieving a growth of 73.5 % in the second quarter 2013 compared to the same period of 2012 and was present in 79.3 % (market share) of smartphones marketed [3].

The health area is a fertile ground for the emergence of solutions based on mobility, once these solutions remove the geographical, temporal and physical barriers, providing the physician access to information where and when needed, allowing health services can be delivered anytime and anywhere [5].

It is noticed that the use of mobile devices plays a very important role in supporting health services , providing greater flexibility from simple processes such as data collection , up to the use of systems to assist in the decision making process with different levels of complexity [2]. In the health one of the global challenges is combating tuberculosis. Only in Brazil is estimated that 4500 people die each year, victims of this disease, which is considered curable and preventable. Even with today's technological advances that are already able to control it, it will be necessary to develop new vaccines and drugs for the elimination of this disease [1].

Taking into consideration all the points described and the motivation of this research , the objective of this work was: - propose an application for mobile devices to facilitate the process of medical decision making, in this case study was used a clinical guideline for tuberculosis in Brazil. The remainder of the paper is organized as follows: The second section contains the theoretical content used in building the knowledge required for the development of this work . In section three the methodology is described. The prototype is detailed in section four. In section five the evaluation performed and results are discussed.

2 Mobile Health and Tuberculosis' Guideline

Worldwide, providing services in healthcare has been transformed by the use of mobile and wireless technologies. A powerful combination of factors is driving this change, where the rapid advances in technologies and mobile applications favored by continued growth in coverage of mobile cellular networks, have increased the number of opportunities for the integration of mobile health services with existing health today [8].

The unprecedented spread of mobile technologies as well as advances in its use to address the challenges of Health contributed to the emergence of mobile health or mHealth as it is known internationally. In the next subsections we discuss a bit more about mHealth and Tuberculosis (disease used as case in this research) and the clinical guideline.

2.1 mHealth

The Health Industry is moving towards an architecture of distributed services, enabling important decisions happen directly at the point of care, the main engine of change , mobile Health (mHealth) [5].

According to the Global Observatory for eHealth(GOE) , the meaning of mHealth is the use of cell phones, smartphones, tablets , personal digital assistants or any other mobile device , such as support to public policies and activities related the area of health [8].

Currently the global mHealth market presents strong growth, overcoming countless barriers created by the global crisis , and may reach the figure of 26 billion dollars in 2017 . This figure makes clear that the mHealth conquered its space on the world stage assistance and medical care , steadily become a tool for transformation of health systems , currently there are almost 97,000 mHealth' applications available worldwide [4]. One of the major problems faced today by health professionals is access to quality information where and when needed. To address this difficulty , the Health industry in mHealth found a powerful ally , able to provide the necessary access people wherever they are [5].

Some platforms have become benchmarks for the development of applications for mobile devices , and among these is the Android Platform [6] that was used in prototyping the application of this work.

2.2 Tuberculosis

In 2003 , tuberculosis was elected by the Ministry of Health in Brazil as a priority public health problem being tackled. That same year, the budget of the National Tuberculosis Control Programme (NTCP) was increased by more than 14 times , in addition to technical and administrative measures such as encouraging the participation of civil society in controlling this disease and the expansion and upgrading of the NTCP team [1].

As a guideline for tuberculosis in Brazil , there is the " Manual of Guidelines for Tuberculosis Control in Brazil ," published in 2011 by the Brazilian Ministry of Health . This document consists of a manual of recommendations that should guide medical management related to tuberculosis , to be followed by health professionals within the Unified Health System [1].

3 Methodology

It is an applied research, which is to use the acquired knowledge to solve real problems of the current context. As for his approach was qualitative and quantitative. The research methods that guided this work were bibliographical research, case study and prototyping. This research involved the participation of an expert in the area of health, who assisted in matters relating to this area. The case study was based on the Brazilian guidelines for tuberculosis, more specifically, the "Manual of recommendations for the control of tuberculosis in Brazil ", published in 2011 by the Ministry of Health [1].

The evaluation of the prototype was performed by three specialists, experts in primary care and in tuberculosis, through a questionnaire. Thus, it was possible to identify their perception about the proposed solution. For data analysis, a quantitative and qualitative approach were applied.

4 Tuber's Prototype

When a doctor receives a patient with symptoms of tuberculosis in health care in Brazil (primary care), he needs the help of clinical guidelines that the ministry of health issued to aid your decision making. These guidelines are printed. This consultation procedure of how experienced the doctor is time consuming, and eventually affects the productivity of the doctor. Thus it was decided to develop an prototype for mHealth called Tuber. This application was developed based on main rules taken from clinical guidelines and modeled with the help of medical expert in this disease.

The architecture of the prototype was developed as a client- server architecture, therefore, is divided into two packages : 1) as a client, we have an application for mobile devices with Android operating system (hereafter in the text this article will be referred to as mobile application), and 2) the server side, which is formed by a java application containing a web service (WS) that communicates with a database and provides services to the mobile application (hereinafter forward the text of this article will be referred to as backend).

The backend has the principal responsibly, providing services that enable the mobile application to access the existing database server information. For its development we used the Java and Axis2 1.6.2 programming framework. Thus, it was possible to easily build WSs in standard Simple Object Access Protocol (SOAP) , which is used protocol for exchanging structured to be moved from one device to another through WS information . As a framework for object - relational mapping opted for the Hibernate 4.2.6, by this encapsulate all interaction with the database . This Java application runs on an Apache Tomcat 7 server , and uses a MySQL Community Server 5.6 database. The mobile application was developed based on the Model View Controller (MVC), which separates the application into three layers . Therefore, following this pattern are: (a) the layout XML files representing the View layer, (b) the activities represented Controller, and (c) the classes of the model represented Model.

Even using the development platform Android 4.3 SDK, the application is designed to run on mobile devices running Android OS 2.2 or higher. As a database for the application, the option chosen was the SQLite, because this is now natively supported by Android . Until the version used in this work, Android has not had native support for interaction with WS. Thus, for the construction of the classes necessary for communication with the WS provided by the backend, the library ksoap2 3.0.0 was used.

4.1 The Clinical Guideline Tuberculosis : Case Study

To evaluate the operation of the prototype developed for this work , it was necessary create the content related with Health. Therefore,the Brazilian Guidelines for Tuberculosisas was used as case study.

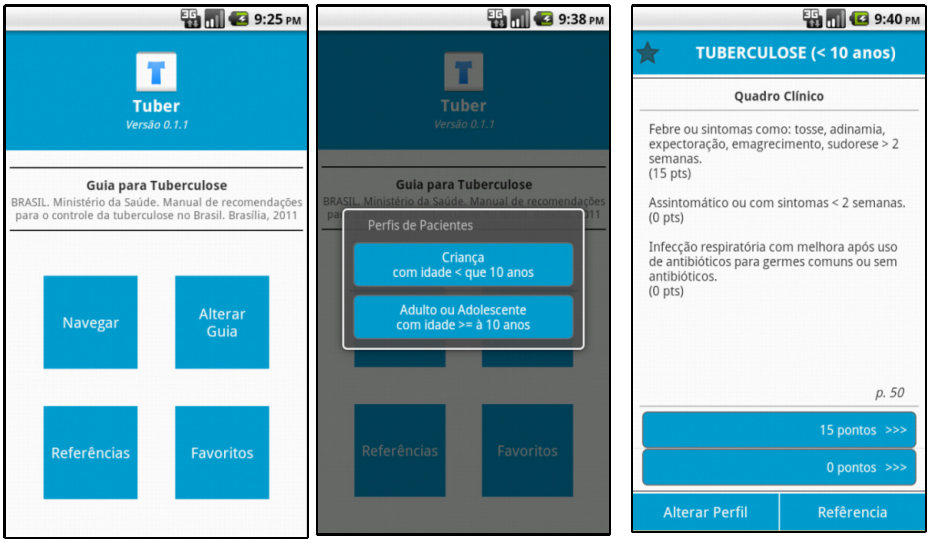
The process of developing the Tuber application was strongly based in the support provided by clinical specialist, who through weekly meetings, helped directly in the

definition of what parts of the guideline should be used and how they should be organized in the application. The definition of the content was focused on Primary Care to Health.

As a source of information , we chose to use, as faithful as possible , the content of the guideline. This constructive process gave rise , in addition to the description of the guideline itself through 146 items (small parts of the guideline) , divided between the two patient defined profiles: 1) *" Children under the age of ten years*" and 2) "*Adults or Teens with greater than or equal to ten years old* ". During the prototype's specification phase, the specialist cited as a difficulty encountered the need to manually perform the calculation of the scoring system used for the diagnosis of tuberculosis in children. This system consists of five variables : 1) **Clinical Situation**: if the Clinical Situation is symptomatic then is assigned 15 points, but if it is asymptomatic is assigned 0 points; 2) **Radiological Situation**: if the Radiography presents condensation and infiltration for more than two weeks then is assigned 15 points, if it is less than two weeks is assigned 5 points and if radiography is normal then is assigned 0 points; 3) **Contact with Tuberculous Adult**: brand yourself 10 points if had close contact over the past two years and 0 points if it was casual or negative ; 4) **Tuberculin Test**: if the result was greater than or equal to 5mm, is assigned 15 points, if less than 5mm is assigned 0 points , and 5) **Nutritional Status**: if the patient presenting severe malnutrition is assigned 5 points, with standard is assigned 0 points . By the sum of points obtained in each variable , we obtain the final result, where : 1) if the result is greater than 40 points the patient should starts treatment ; 2) if the result is between 30 and 40 points the patient should starts the treatment according doctor's decision, and 3) if the result is less than 30 points, the treatment is not necessary.

To help the doctor in this task, a flow was definide and this flow was based on a data structure with a tree format, where we have : 1) the questions representing nodes (Item), 2) the score obtained as edges (ITEMLIST) and 3) the final score and its interpretation as sheets (Item). Thus, to properly answer the questions (fig. 1(c)), we can navigate the created flow to reach a final result containing the diagnosis of tuberculosis in children. Similarly , other flows from the guideline were analised and new ones were also created, as an example we can mention the diagnosis performed on adults using the tuberculin skin test (TST) , the test result can be obtained by the interpretation of the information presented by a table contained in the guideline. This table is available in the mobile application through a flow of navigation to answer questions regarding the result of the TST and the patient's age, then groups of patients to be treated for Tuberculosis are displayed.

Fig. 1 shows some interfaces of the prototype, they assist the doctor during patient consultation and diagnosis regarding Tuberculosis. Figure 1(a) presents the first interface that doctor has contact when starts the Tuber's application, figure 1(b) presents the second interface where the doctor should informs if the patient is a child or an adult (this information helps the system decide what flow should be presented in the sequence), figure 1(c) presents the third interface where the doctor gives some patient informations, and has the result to take decision based on tuberculosis' clinical guideline (the guideline's page is informed on this interface).



(a) (b) (c)

Fig. 1. Tuber's Interfaces

5 Evaluation

The evaluation of the prototype was conducted through a questionnaire. The questionnaire was applied to three medical from family and community, one being a professor of public health. The questionnaire comprises sixteen questions, which are divided into three groups.

The group formed by the questions one through six have aimed to collect data on the profile of the respondents and their familiarity with the use of applications on mobile devices . This first group consists of four questions of free choice and two free response. Having as objective the evaluation of the prototype acceptance by the respondents , we have the second group which is composed from question number seven to fourteen, comprising : (a) six questions that use a Likert scale of five points for the answer , where the value " 5 " means " Strongly Agree " and " 1 " means " Strongly Disagree " , (b) a matter of free choice , and (c) a matter of free response . Finally , in the last group we have questions 15 and 16, to collect users comments and suggestions for improvement to the application and to the " Guide to Tuberculosis ".

The sample of experts which agreed to participate in this evaluation was three. The profile of this non-probabilistic sample was composed primarily of health professionals, two of whom are also professors. All have as the practice area of family and community medicine, having between 5 and 17 years of expertise in this area.

The first group of questions investigated the familiarity of the respondents with the use of applications on mobile devices such as smartphones and tablets . With responses submitted, we concluded that all experts already were familiar with this context and already use applications targeting the area of Health on their smartphones.

The second group of questions investigated the acceptability of the developed prototype . Usability is an important factor in the acceptance of any software. Within this context were proposed questions 7, 8 and 9. All respondents agreed completely that the application is easy to understand (question 7) and easy to use (question 8) , containing clear and objective features (question 9). According to question 10 , there was a massive agreement among raters, with the possibility of the application developed replace the use of printed guideline. It was also obtained the full agreement of the respondents in question 11, where was asked about the possibility of adding and changing content directly by health professionals, thus allowing for more flexibility and consistency. A point worth mentioning because it is directly connected with the purpose of this research is the fact that all respondents totally agree (question 12) that the prototype created efficiently assists in the decision making process of the health professional.

Finishing the second group, question 13 tried to verify from the respondents if they would use this application for patient care, and all answered yes. Question 14 asked the justification for the use or not use the application.

Table 1. Contribuition by evaluators for question 14

Evaluator	Contibuition
1	*"The application has the practicality to summarize and organize the information needed and more relevant in the outpatient management of patients with suspected and diagnosed with tuberculosis. The fact of being in the cell and can be carried in the pocket also contribute to use."*
2	*"I would use the application during patient care, because it allows access to the information they need to diagnose and treat people with TB and / or latent tuberculosis infection in a clear and objective manner. This facilitates my work and optimizes patient care time."*
3	*"The application facilitates the conduct of research for each case, considering that the primary care professionals working with several other health problems and can not write everything that comes to meet that specific disease."*

6 Conclusions and Future Work

The use of mobile devices is increasing gradually , making these devices a new source for developing solutions in various technologies . In Health , mHealth is gaining more prominence by facilitating access to information when and where needed. The Tuber application confirms the feasibility of the proposed solution, and presents extensive

content covering since the diagnosis of Tuberculosis up to their treatment , using information obteined from the Brazilian's Guide for Tuberculosis. All experts agreed that the application is easy to understand and use, and it assists efficiently in the process of decision making of health professionals facing the demand for treatment in health centers, allowing quick access to the information they need to diagnose and treat people with tuberculosis. The proposed solution has demonstrated to be useful for patient care, to optimize and facilitate the work process, providing more time for patient care.

After performing all the steps of this work, and especially the massive acceptance that the application obtained from your target audience, it is understood that the objective of this research has been achieved. Also mean that the solution presented here, is directly connected to an existing need for the professionals of health, who wish to streamline and facilitate the process of decision making so that they can devote more time to patient care. Completing this survey, it is possible to identify how future work : a) develop a web application that allows creation and editing guides , directly by health professionals ; b) carry out the validation of the prototype by means of a clinical trial ; c) adapt the application for use on tablets and create versions for Windows Phone and iOS platforms.

References

1. Brasil. Ministério da Saúde. Manual recommendations for tuberculosis control in Brazil. Brasília (2011), http://portal.saude.gov.br/portal/arquivos/pdf/manual_de_recomendacoes_tb.pdf
2. Grasso, M.: Clinical applications of hand held computing. In: Proceedings of the 17th IEEE Symposium on Computer-Based Medical Systems (2004)
3. IDC. Apple Cedes Market Share in Smartphone Operating System Market as Android Surges and Windows Phone Gains, According to IDC. Framingham (2013), http://www.idc.com/getdoc.jsp?containerId=prUS24257413
4. Jahns, R.-G.: The market for mHealth app services will reach $26 billion by 2017. Berlin (2013), http://www.research2guidance.com/the-market-for-mhealth-app-services-will-reach-26-billion-by-2017/
5. Krohn, R., Metcalf, D.: mHealth: from smartphones to smart systems. HIMSS, Chicago (2012), http://www.healthsen.com/mHEALTH_PREVIEW.pdf
6. Lee, W.-M.: Beginning Android application development. Wiley, Indianapolis (2011)
7. Mendiola, J.: Los smartphones superan en ventas a los móviles convencionales por primera vez. [S.I.] (2013), http://es.engadget.com/2013/04/26/smartphone-moviles-idc-q12013/
8. World Health Organizationm (WHO). mHealth: New horizons for health through mobile technologies, Geneva. Global Observatory for eHealth series, vol. 3 (2011), http://www.who.int/goe/publications/ehealth_series_vol3/en/index.html/