Analysis of Mobile Applications for Self-healthcare of Panamanian Patients with Hepatitis

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Abstract. Hepatitis B infection and liver disease are the leading causes of cirrhosis and liver cancer in the world. The use of computer solutions applied to the medicine is increasing every day. Scientific research in areas of health, as well as the development of new technologies involving smartphones and sensors, is making possible self-management of health. In this context, interest in mobile health (mHealth) applications for self-management of diseases is growing. Hence, this research aims to analyze this kind of applications, specifically, those ones focused on hepatitis B. Furthermore, an ontological model for the effective management of knowledge of the hepatitis B domain is proposed in this research.

Keywords: Ontology · Hepatitis B · Mobile applications · Self-healthcare

1 Introduction

Hepatitis is a viral infection that causes acute and chronic disease, and sometimes death. Several types of virus have been classified: hepatitis A (HAV) and hepatitis B (HBV), hepatitis C (HCV), hepatitis D (HDV), hepatitis E (HEV), hepatitis G (HGV) [1].

Hepatitis B is the most common liver infection in the world. It causes hepatitis B virus (HBV) [2], which attacks the liver and injures it. The hepatitis is passed through the blood, unprotected sex, needles shared or reused, and from the infected mother to the newborn baby during childbirth. Most infected adults can get rid of the hepatitis B virus without any problem, but some adults and most infected infants and children cannot get rid of the virus which causes chronic infections.

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When this disease attacks the liver, it blocks the passage of bile by breaking down fat, disrupting its function of removing toxins from the blood, producing various important substances and storing and distributing glucose, vitamins and minerals. According to the World Health Organization (WHO), the hepatitis B virus infects 10 to 30 million people worldwide every year, most of them children and adolescents [3]. About 2 billion people have been exposed to the hepatitis B virus through contact with blood or infected organic fluids [4]. The infections can occur during labor, sharing infected needles, or transfusions of infected blood [5]. Symptoms of hepatitis B may not appear for up to 6 months after the time of infection. The early symptoms include: lack of appetite, fatigue, body weakness, low fever, nausea, vomiting, dyspepsia, abdominal discomfort, bleeding tendency, swelling, abdominal edema, yellow skin, turbid urine and jaundice.

The symptoms will disappear in a few weeks to months if the body is capable of combating the infection. Some people never get rid of HBV; this is known as chronic hepatitis B. People with chronic hepatitis may not have symptoms and not know they are infected. Some people may submit symptoms of chronic liver damage and cirrhosis of the liver.

In addition, hepatitis B can cause psychosocial problems, such as anxiety and withdrawal of interpersonal relationships. Such physical, psychological problems, and socio-economic problems constantly affect activities and quality of life of patients [6].

If this disease is not treated properly, it can result in death due to its many complications [7] in most developing countries (sub-Saharan Africa, for example) chronic hepatitis B represents between 8% and 15% of the population. In these countries, liver cancer associated with the hepatitis B virus is the third leading cause of cancer death.

In Panama, the incidence of hepatitis B virus reported annually is relatively low, compared to other chronic degenerative diseases, but has had a variable behavior in the last six years and it is important for health organizations to maintain a balance of the patients who have the disease in order to monitor them and stop spreading [8]. Next, Table 1 shows a balance of the number of deaths due to the hepatitis B virus, in the last 6 years in Panama.

Hepatitis B is the most common virus in Panama, 14 cases of cellular hepatic cancer were diagnosed in 2014, according to statistics from the Ministry of Health (MINSA-Panama).

Nowadays, the convergence of several areas of knowledge [9] has led to the design and implementation of computer systems using tools such as tablets, mobile phones, Internet, wireless networks [10], sensors attached to the body [11] and other devices that allow to perform monitoring [11] of various factors such as medication intake, blood pressure, and blood glucose, among others.

The management of ontological models that can shape the knowledge of domain experts, especially those of hepatitis B, is of utmost importance. Based on this understanding, we propose an ontology in order to semantically describe relations between concepts in hepatitis B domain. Ontologies allow static knowledge representation and enable knowledge sharing and reuse, thus reducing

Table 1. Number of death in Panama attributable to hepatitis B.

Year	Quantity of deaths
2009	250
2010	480
2011	279
2012	365
2013	268
2014	214

the effort needed to implement expert systems. Ontologies are currently being applied in several different domains, such as sentiment analysis [12], recommendation systems [13], natural language interfaces [14], or bioinformatics [15].

The use of these information technology solutions applied to health is increasing and there are many applications focused on the user, these applications are known as mobile health [16] or mHealth [17]. The main objective of these applications is that through any smart device it can be downloaded, installed and used, with the advantage that most of them are free. Also, mHealth applications bring useful tools for health care and for a better quality of life, such as monitor the heart rate, consult the vaccination schedule, take control of chronic diseases such as hepatitis B, and remember taking a drug and even triggering it quickly in the face of an emergency [18].

By the year 2020, 6.1 billion people, or about 70% of the world's population, will use smartphones, and at least 50% of smartphone users will use health-related mobile applications [19].

Therefore, we present an in-depth analysis of the features of Hepatitis B mobile applications. In addition, we contrast the requirements derived from evidence-based recommendations with the functions available in existing interventions.

2 Background

Nowadays, the main causes of death in Panama are mostly chronic degenerative diseases: cancer, cardiovascular disease, diabetes mellitus and hepatitis B. The WHO estimates that 46% of global disease is due to chronic diseases [20].

Panama started in the Telemedicine area in 1999, when the Documentation and Medical Information Center was created in the Faculty of Medicine of the University of Panama (UP).

In MINSA-Panama, there is a system of teleradiology, which has been operating for almost 10 years, the purpose of this project is to make teleconsultations through e-mails, queries that are sent from different regions of the interior of the country. Nowadays, Panama has a National Telemedicine and Telehealth Program, of the MINSA, where teleradiology is developed more than anything else.

There is a lack of studies in the self-management [21] of the health of patients with the virus of the hepatitis B. Although they exist in other specialties like diabetes.

When a patient with the hepatitis B virus becomes ill, clinical symptoms often do not manifest clearly in their entirety until the liver damage has progressed. In this situation, many patients do not take the disease self-management seriously, they do not inform themselves about the causes, or possible procedures, as well as they lose follow-up appointments with their specialists or they do not follow the treatment adequately due to a lack of knowledge of the disease [6].

Panama is the fourth country in the world that has the highest penetration of cellular telephony, based on the Global Index of Information Technology. The country is located below Honkong, Arabia Saudi and Montenegro. According to sources from the Ministry of Economy and Finance of Panama (MEF) and the National Institute of Census Statistics, 83.9% of households had at least one telephone cell phone.

Table 2 shows the proportion of households with cellular telephony, according to provinces and indigenous districts (data obtained from the 2010 Census).

Table 2. Proportion of households with smartphones.

Provinces and indigenous regions	Proportion of households with smartphones (%)
Total provinces	**83.9**
Bocas del Toro	72.7
Cocle	279
Colon	365
Chiriqui	85.6
Darien	71.7
Herrera	81.8
Los Santos	80.5
Panama	90.8
Varaguas	70.9
Indigenous regions	
Kuna Yala	46.5
Embera	37.3
Ngöbe Bugle	26.9

With these high percentages, the strong dependence of Panamanian households on cellular technology was sustained. On average 83 per 100 households or 8 per 10 had a smartphone.

Even in the Indian regions, where the cultural aspect is very discriminatory when deciding which technology to use, due to bias or myths, the demand for mobile telephony service was very high.

Therefore, it is important that patients with the hepatitis B virus perform self-care in order to manage their own health and well-being. Self-care is an extended concept that includes activities related to the prevention and treatment of chronic diseases, rehabilitation and health.

Adequate and active self-care of patients [22] can positively improve prognosis. Reports have indicated that knowledge of a disease [23] and self-efficacy are the main factors that can improve the self-care of patients.

However, studies have revealed low levels of knowledge of the disease in patients with hepatitis B virus, or negligence of self-care in these patients, as well as in the transmission of hepatitis virus B [24].

3 Method

3.1 Search Strategy

The search was based on online stores for mobile applications, using the search terms related to Hepatitis B to ensure that all relevant applications were detected. We chose the following keywords related to the hepatitis B virus: hepatitis B, hepatology, HBV and HCV.

This review was focused on the operating system Android. Therefore, the analysis was carried out using the Google Play Store for Android applications.

3.2 Selection Criteria

The main inclusion criteria were quantity of downloads, last update, rating, number of opinions, functionality, usability, and price. Also, We excluded applications not centered on the specific condition, based on others language different that Spanish, or those included in the category of games, entertainment, or music.

3.3 Evaluation and Assessment of Application Functionalities

Next, each one of the selected functionalities for the analysis are presented.

1. Sending reports to the doctor. This refers to the ability of the application to collect certain information and issue reports to the doctor or the person in charge of the patient's treatment.
2. Drug database. It includes commonly used reference drugs in hepatology, with emphasis on practical advice and common complications.
3. Analysis of formulas and equations. The applications present information calculations, risks or projections about diseases related to hepatitis.
4. Reminder of medication intake. This feature allows the application to send reminders of the medication to be taken by the patient according to the doctor's prescription.
5. Data storage and processing. This feature allows to store information directly in certain storage services of the phone and then perform some analysis.

6. Social networks. This functionality establishes a connection with social networks such as Facebook or chat rooms in order to communicate with other patients, send messages related with the progress achieved through the treatment followed.
7. Alerts for testing. This allows scheduling the days on which the patient should do medical examinations.
8. Reminder visits to the specialist doctor. This functionality allows the patient to receive reminders about visits to the specialist.
9. Health tips. This refers to the ability of the application to provide preventive health advice, decision-making and general information on the treated disease.
10. Access to teaching materials. Applications have access to medical journals.

4 Results

This section presents a comparative analysis of the mobile applications oriented to the management of hepatitis B. The main objective of this analysis is to know the characteristics and functionalities provided by the most popular applications in the virtual stores, and determine the main Advantages and disadvantages of these.

The applications studied are summarized in Table 3. As can be seen, iLiver is the applications more download and more popular with 50000 downloads and 150 opinions. On the other hand, the application with the highest ranking was VitalTalk Tips with a score of 5. All these applications analyzed have a score of 3 to 5 in rating. Regarding to the price, applications can be purchased from 2.33 to 56.20 dollars.

Table 3. Selected applications.

Apps	Type of mobile device	Cost	Download	Rating	No. Opinions
EASL LiverTree	Android 4.1 (and higher)	free	1000	4.5	10
GIT & Hepatology News	Android 4.0 (and higher)	free	5000	4.1	14
Healthy B	Android 2.2 (and higher)	free	5000	3.5	8
Hepatitis B Disease	Android 2.2 (and higher)	free	10000	3.9	15
HepB Story	Android 4.0 (and higher)	free	500	3	2
iLiver	Android 2.2 (and higher)	free	50000	4.4	154
iLiver Tablet	5000	free	1000	4.5	20
inPractice Hepatology	Android 4.0 (and higher)	free	500	5	3
LiverCalc	Android 2.2 (and higher)	free	10000	4.2	44
Liverpool HEP iChart	Android 4.0 (and higher)	free	10000	4.6	65
ScaleHBV	Android 4.1 (and higher)	free	50	4	1
STD Info, Symptoms & Testing	Android 2.3.3 (and higher)	free	5000	3.4	7
The Journal of Hepatology	Android 4.4 (and higher)	free	1000	4.8	6
Understanding Hepatitis B	Android 2.3.3 (and higher)	2,33	5000	4.1	12
VitalTalk Tips	Android 4.2 (and higher)	free	500	5	7

Table 4 shows the results from the analysis of the functionalities that were studied in each application selected.

Table 4. Features analysis of selected apps.

App's	Features									
	1	2	3	4	5	6	7	8	9	10
EASL LiverTree										x
GIT & Hepatology News			x	x			x	x	x	x
Healthy B			x	x			x	x	x	x
Hepatitis B Disease										x
HepB Story - Menzies									x	x
iLiver			x						x	x
iLiver Tablet			x							x
inPractice Hepatology		x							x	x
LiverCalc			x		x				x	x
Liverpool HEP iChart		x							x	x
ScaleHBV										x
STD Info, Symptoms & Testing									x	x
The Journal of Hepatology									x	x
Understanding Hepatitis B	x		x	x	x	x	x	x	x	x
VitalTalk Tips öbe Bugle									x	x

4.1 Classification of the Application

There is a very important issue in this context of health self-management applications [25] and it is the reliability of health information on the Internet addressed to non-professional users, this is a relevant topic and widely debated by professionals and patients themselves.

We have proceeded to classify the mobile applications [26] according to a series of criteria that generalize basic elements that constitute them and for these applications to be accepted by the users in general, which are: use, interest and confidence. This study classified several applications into different categories as explained below.

Self Care. The performance of self-care includes the daily activities that a patient performs to maintain his/her health. In order to measure the performance of self-care, we reviewed of different applications, especially those containing elements or modules related medical instructions, medication, manage symptoms and complications, follow up appointments, record and analyze liver function

tests (ALB Albumin, ALT Alanine Transaminase). The applications that have elements that can be identified in this category and are: iLiver, Understanding Hepatitis B, LiverCalc and Healthy B Handbook.

The Understanding Hepatitis B application contains many of the elements identified for self-care of the patient, allows to register certain analyzes of patients with hepatitis (ALB, AST etc.) and send them to the patient for review. Schedule the examinations that the patient should perform, as well as reminder of appointments and taking medications.

The Healthy B Handbook application contains some elements within this category of self-care. For example, a module that calculates the "liver cancer risk forecast", records the levels of ALT and other antigens and projects the probability of having liver cancer. Also, it has module of reminder of exams to be realized, visits to the specialist and taking of medicines.

The LiverCalc application includes the formulas and equations used in the daily evaluations of patients with liver disease, such as cirrhosis, hepatitis, and liver transplantation. This innovative calculator allows calculating 17 hepatic parameters in a single panel, ensuring convenience and accuracy. LiverCalc facilitates the organization and processing of patient data. It is an application intuitive and very easy to use.

Drug Database. In hepatitis therapy, patients take more than one drug at the same time and other drugs to treat coexisting conditions. Many of the drug combinations have the potential to interact and this can affect patient safety or treatment efficacy. Two of the applications analyzed, inPractice Hepatology and Liverpool HEP iChart, fall into this category.

With regards to inPractice Hepatology, it is a complete database of drugs. The physician specifies the drug and the application brings the required information. It was approved by the Food and Drug Administration (FDA). Also, this application has access to summaries of PubMed which is a database with information and clinical trials.

Liverpool HEP iChart contains a database of drugs, where the patient or doctor selects the medicines to be evaluated and through a dashboard shows with color the results after of analyzing them, which determine if there are opposite reactions between them. The results are presented as a system of "Traffic light" (red, yellow, green) to indicate the recommendation.

Knowledge of the Disease. To be aware of his/her treatment and self-management of the disease, the patient must have access to information that allows him/her to know everything related to his/her disease. Most of the applications analyzed fall into this category, approximately 95% are focused on teaching and/or training.

The Hepatitis B Disease application gives the patient complete information about the disease, such as symptoms, causes, diagnoses, treatments and prevention.

Understanding Hepatitis B is an informational application about hepatitis B disease and has a FAQ section.

STD is an application that is approved by the FDA and allows a patient anonymously through a series of questionnaires to determine what type of sexually transmitted disease can have, including hepatitis B.

HepB Story provides information on how the virus. Also, it provides information about stages of illness, symptoms, as well as details on immunization and treatment. There is also a section with information for women dealing with mother-to-child transmission of the virus and ways to prevent it.

SCALE HBV provides counseling guidance to address patients' questions and concerns about the prevention, testing, and treatment of hepatitis B.

The Journal of Hepatology application publishes original papers, reviews, case reports and letters to the Editor concerned with clinical and basic research in the field of hepatology. We also find the iLiver application that is for professional use that provides immediate medical information and clinical recommendations for medical experts. This application contains information specifically related to liver disease.

It is important to note that of the applications analized, only two of them have access to PubMed that allows access to bibliographic databases such as MEDLINE, these applications are GIT & Hepatology News and inPractice Hepatology.

Applications for Doctors. This category consists of applications that can provide useful information to the medical specialist such as reports and statistics. This information allows to the specialist to carry out monitoring of patients with diabetes. SCALE B is an application that provides clinicians with an easy way to link patients with local HBV specialists based on zip code, city or state of patients.

The main objective of InPractice Hepatology is intended to meet the needs of medical specialists, hepatologists, gastroenterologists, infectious disease clinicians and others who treat patients with viral hepatitis, including HBV and HCV. The iLiver application provides immediate medical information and clinical recommendations for medical experts.

Social Forums/Blogs. This category consists of applications that allow interaction between people with hepatitis B, aiming to share information and experiences. An example of this application is "Understanding Hepatitis B".

5 Ontological Model

In this work, we present a model based on the construction of an ontology for the hepatitis B domain. This ontology represent a detail every facet of the Hepatitis disease. Among the main aspects included are types of patients depending on the level of reagent obtained in the tests: Anti-HBc, Anti-HBs and HBsAg; the phenotypes of the disease describe both the causes as well as the symptoms of the disease; and treatments administered to a patient in a chronic condition,

either antiviral or injectable. This ontology is described using the second version of the Web Ontology Language (OWL2). The ontology defines 37 classes, 3 data type properties, 8 object properties, 8 individuals and 183 axioms. An excerpt of the ontology is shown in Fig. 1.

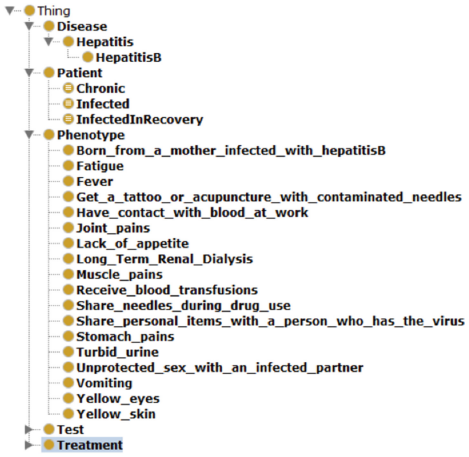

Fig. 1. Extract the ontology of the hepatitis B domain.

In the model, we can see, the Phenotype hierarchy represents observable characteristics of the Hepatitis B disease, such as symptoms or causes. For example, some of the symptoms of the Hepatitis B disease are Fatigue, Fever or Muscle-Pains. On the other hand some of the causes are Share-Needles-During-Drug-Use, Receive-Blood-Transfusion or Long-Term-Renal-Dialysis. All these classes are related to the Hepatitis B class by means of the isSymptompsOf and isCauseOf object property.

The Test hierarchy represents the kind of tests that are done to a patient with Hepatitis B (i.e. Anti-HBs, Anti-HBc and HBsAg). The values of these test determine the level of the disease into Chronic, Infected or InfectedInRecovery that are equivalent classes. For example, if all the tests are positive for a particular patient then the level of her/his disease is Chronic.

It is important to mention the relationship isTreatmentOf that represents the type of treatment that should be recommended to patients with Hepatitis B. There are different treatments, such as, Antiviral, Injectable or Oral.

Finally, the ontology includes some axioms to inferred new knowledge such as the kind of recommended treatments from the state or level of the disease.

6 Conclusion

Although the Central America region is under development, Panama country has important technological and communications infrastructure that allows it to advance and adapt new services based on mobile devices, as well as Internet services.

There is also high demand for public health services and the number of patients at different levels of hospital care is growing rapidly, especially those with chronic degenerative diseases such as hepatitis B.

The use of health technologies, e-health and m-health can play an important role in the health strategies of the country. A strategy should be definitively established to regulate and propose appropriate methodologies for the use of health technologies, taking care of the patient's intimacy with potential chronic diseases such as diabetes.

It is also necessary to establish an evaluation agency in health technology and to adequately promote services that allow the Panamanian population to be educated in the adoption of new health care services.

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