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AN INFORMATION SYSTEM FOR REGISTRATION AND CONSULTATION OF LIVER PROFILE TESTS IN THE HOSPITALS OF THE DEPARTMENT OF HUILA - COLOMBIA

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ABSTRACT

Hospitals in the Department of Huila in Colombia need hospital information systems that allow them to guarantee the integrity and readability of patients' information and also make it possible for health information to be available at any point of care, regardless of the institution provider of services where the patient is cared for. Unfortunately, the Huila hospitals do not yet have these information systems; which is why health care staff use old-fashioned, complex and unstructured methods to store data about all types of results and tests performed so that can be examined and analyzed by a physician and then he cans make decisions. In this project an information system was implemented to optimize the process of conducting the hepatic profile tests in Huila hospitals in order to improve the organization of the results, making access to these results much more comfortable and efficient. The HL7 standard set was used as a guide for good interoperability and to make the system scalable. Access can be made through any web browser or any device due to a responsive web design was used. The information system allows access to the data of a specific patient and it is possible to export information from the database to obtain different statistics.

Keywords: information system, hepatic profile, web services, HL7-FHIR.

1. INTRODUCTION

The liver is one of the largest organs in the body. It is responsible for helping the body to digest food, store energy and eliminate toxins. The hepatic profile, called hepatogram also, is a blood test that has been developed to evaluate the liver function. So then, liver diseases in the body may be diagnosed and after this, through drug treatments, control the liver function in patients who require it.

The term "hepatic disease" applies to many diseases that avoid that the liver works or works properly [1]. Abdominal pain, yellowing of the skin or eyes (jaundice) or abnormal liver function tests may suggest that the patient has liver disease. There are many types of liver diseases. Some of them are caused by viruses, such as hepatitis A, hepatitis B, and hepatitis C. Others may be the result of drugs, poisons, toxins, or by drinking too much alcohol [2].If the liver forms scar tissue, due to a disease, this is called cirrhosis. In addition, cancer can also affect the liver. Other liver diseases may be hereditary, such as hemochromatosis. As already mentioned, liver function tests can check or diagnose for liver damage [3]. Some pathologies of the liver are [4]:

- Alpha-1 antitrypsin deficiency
- Amebian liver abscess
- Autoimmune hepatitis
- Biliary atresia
- Cirrhosis
- Coccidioidomycosis
- Agent delta (hepatitis D)
- Drug-Induced Cholestasis
- Fatty liver disease
- Hemochromatosis
- Hepatitis A
- Hepatitis B
- Hepatitis C
- Hepatocellular carcinoma
- Fatty liver disease due to alcohol consumption
- Primary biliary cirrhosis
- Pyogenic hepatic abscess
- Reye's syndrome
- Sclerosing cholangitis
- Wilson's disease

The tests that may be part of the liver profile are the following:

- ALT or GPT enzyme: this enzyme rises when the liver cells are damaged.
- AST or GOT Enzyme: the presence of this enzyme in the blood increases when liver cells are damaged.
- Gamma-GT or GGT: the enzymatic activity Gamma-GT can grow in cases of cirrhosis or biliary lithiasis.
- LDH: this is an enzyme that can increase its level in blood for different reasons, among them, liver abnormalities.
- Alkaline phosphatase: this enzyme is found in various tissues and can be elevated for a variety of reasons, including biliary lithiasis, cirrhosis, bone problems, growing children and adolescents, etc.
- Bilirubins: the liver is in charge of processing bilirubins, so these are always included within the liver profile. When the liver is not functioning properly, bilirubin may be elevated. The increase in bilirubin may also occur in cases of hemolytic anemia or jaundice of the newborn.
- Total proteins and albumin: these are also frequently included in the liver profile tests, since they are

synthesized in the liver and their decrease in blood may be due to liver failure.

This article presents the design and implementation of an information system for the registration, organization and analysis of the results of liver profile tests in Huila hospitals. The main objective of the work is to create a healthcare information system - HIS, which allows register the laboratories' staff, physicians and patients and allows also register, consult and authorize the exams of hepatic profile. The data can be entered through the Hospital's local area network, as well as from any remote computer or device (Smart phone or Tablet) connected to the Internet. The designed HIS follows the guidelines of the HL7-FHIR standard, the most widely worldwide distributed, ensuring easy interoperability with almost any other hospital information system. According to the World Health Organization - WHO, if better information is available, better decisions will be made and the population will be able to have better health; this is what justifies the need for more robust HISs for hospitals in Huila. As information systems evolved, information systems were available that could present reports related to the health of each patient, statistics on the data obtained in the examinations performed, as well as medicines and treatments formulated by physicians. Examples of these systems are the Care2x (Open Source Hospital Information System), first published in 2002 by Elpidio Latorilla and the Mexican Government's Information System for Hospital Management (SIGHO), which began only in 2005 [6-7].In the Department of Huila this technology is just beginning to be implemented; therefore, this work can be considered as an initial contribution in the area.

2. METHODOLOGY

General design of the information system

For the development of the Information System its propose the system described in Figure-1, in which MySQL is used to store the data, a web server to control the platform and the web clients requesting a connection. Web clients can request the server to send pages from any device with internet connection; these devices can be desktop computers, laptops, tablets or smartphones.

In the stages of the project development process, the database was first designed taking into account the variables and records necessary for the correct functioning of the system. Then the control and the service of the web pages were defined through the server along with its visual design. The system follows the HL7-FHIR standard for sending medical information, so tools like MirthConnet can access the information using their standard-based connection protocols [8].

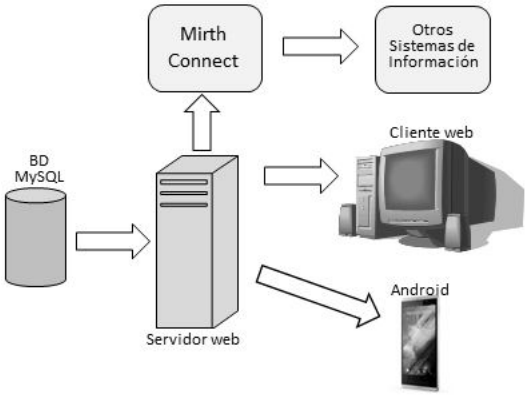

Figure-1. Information system architecture.

HL7-FHIR standard

HL7-FHIR (Health Level 7 - Fast Healthcare Interoperability Resources) is a standard that describes "resources", data formats, and electronic health records exchange (EHR) elements. The standard was created by the international health standards organization HL7. One of HL7-FHIR's objectives is to facilitate interoperability between different health care systems, so that be easy to provide healthcare information to healthcare providers and individuals through a wide variety of devices, from computers to tablets and cell phones; enabling third-party application developers to develop medical applications that can be easily integrated with existing information systems. HL7-FHIR is relatively easy to deploy, because it uses a modern web-based technology suite, including RESTful, HTML and Cascading Style Sheets (CSS) for UI integration. For data representation JSON or XML can be used and for authorization OAuth can be used [5].

In this paper, JSON was chosen for data representation, which means interoperability with other information systems using the same technology for exchanging EHRs will be simple and guaranteed. However, interoperability with information systems that use a different technology to represent data, such as XML or others can be achieved through a management tool for integration of multiple health information systems, such as MirthConnect [8]. It should be noted that this paper is part of a more ambitious project for the Department of Huila, which seeks to systematize the entire health system, so that interoperability between different health information systems must be guaranteed.

Database server

MySQL is the most popular open source database in the world, making it a reliable and secure option [9]. In addition, it has features such as high scalability, easy operation, high performance among others, making it the ideal choice for the information system needs.

In the project some tables were defined to store information about the users, the status of each session and the information corresponding to the defined liver profile tests. In Figure 2 the described database diagram can be visualized. For the tables of patients, staff and exams, the fields are constructed using the JSON format as defined in

the HL7 standard. The following is a description of each table:

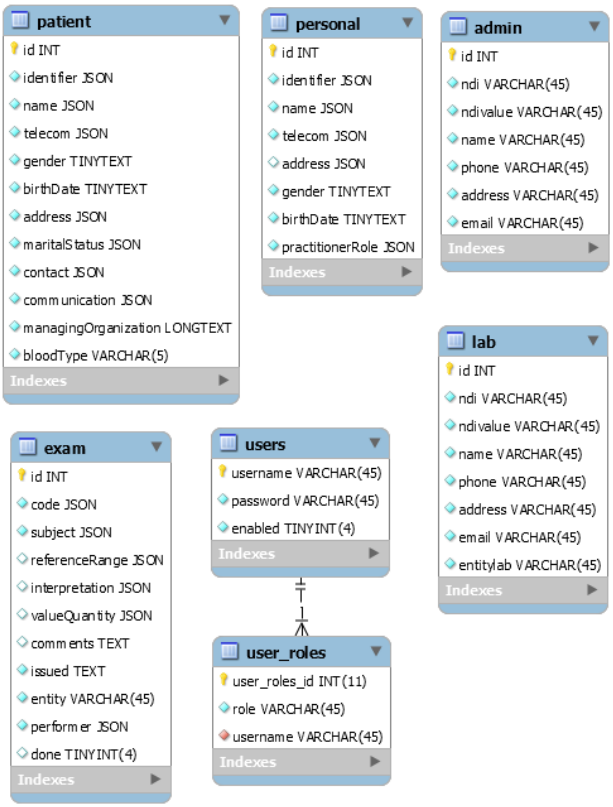

Figure-2. Database tables.

patient: this table stores all the information corresponding to the patients of the platform. For each user the following fields are defined:

- **id**: integer type field that identifies the record.
- **identifier**: JSON field,which stores, according to the HL7 standard, the patient identifier.
- **name**: JSON field,which stores, according to the HL7 standard, the name of the patient.
- **telecom**: JSON field that stores contact information.
- **gender**: String field that stores the gender.
- **birthdate**: String field that stores the date of birth.
- **address**: JSON field storing address.
- **maritalStatus**: JSON field that stores the marital status.
- **contact**: JSON field that stores contact information.
- **communication**: JSON field that defines the language of interpretation of information.
- **managingOrganization**: String field that stores health entity information.
- **bloodtype**: String field that stores the blood type.

personnel: this table stores all the information corresponding to the medical personnel of the platform. For each member the following fields are defined:

- **Id**: Integer field that identifies the record.
- **Identifier**: JSON field wich stores, according to the HL7 standard, the patient identifier.
- **Name**: JSON field which stores, according to the HL7 standard, the name of the patient.
- **Telecom**: JSON field that stores contact information.
- **Address**: Field JSON storing address.
- Gender: String field that stores the gender.
- **Birthdate**: String field that stores the date of birth.
- **PractitionerRole**: JSON field which stores, according to the HL7 standard, the charge of medical personnel.

admin: this table stores all information about the platform administrator. For this table the following columns are defined:

- **id**: Integer field, which identifies the record.
- **ndi**: String field, which stores the administrator identifier type.
- **ndivalue**: String field, which stores the identifier of the administrator.
- **name**: String field, which stores the name.
- **phone**: String field, which stores the phone. **address**: String field, which stores the address.
- **email**: String field, which stores mail.

lab: this table stores all information about the laboratory performing the liver profile examination. For this table the following columns are defined:

- **id**: Integer field that identifies the record.
- **ndi**: String field that stores the identifier type.
- **ndivalue**: String field that stores the identifier.
- **name**: String field that stores the name.
- **phone**: String field that stores the phone.
- **address**: String field that stores the address.
- **email**: String field that stores mail.
- **entitylab**: String field that stores additional information about the entity.

exam: this table stores the information corresponding to the medical exams of the liver profile. For this table the following columns are defined:

- **id**: Integer field that identifies the record.
- **code**: JSON field that stores the type of examination of the liver profile.
- **subject**: JSON field that stores patient information according to the HL7 standard.
- **referenceRange**: JSON field that stores the reference range of the variable to be measured according to the HL7 standard.
- **interpretation**: JSON field that stores according to the HL7 standard the interpretation of the resultsof the variables to be measured.
- **valueQuantity**: JSON field that stores according to the HL7 standard the actual value of the variable to be measured.
- **comments**: String field that stores comments about the exam.
- **issued**: String field that stores the date and time of the exam.
- **entity**: String field that stores the entity providing health services.

- **performer**: JSON field that stores according to the HL7 standard the user of the medical personnel requesting the examination.
- **done**: Boolean field that stores 1 if the test was performed.

users: this table stores user session information. For this table the following columns are defined:

- **username**: field type String that identifies the user for login.
- **password**: String type field that stores the password for the login.
- **enabled**: Boolean field that is 1 if the user is enabled.
- **user_roles**: this table stores the user roles. For this table the following columns are defined:
- **user_roles_id**: role identifier.
- **roles**: String field that stores the role of the user.
- **username (FK)**: String field that identifies the user for the login that corresponds to the document number.

Web platform

The web platform allows users to perform operations to manage the information recorded in the system. There are four types of users, which are defined below:

- **Administrator**: Registered through the website. It is responsible for registering, modifying or eliminating the other users of the platform.
- **Staff**: This type of user can view your basic information and modify your data, also have access to the patient's data, as well as authorize the liver profile tests and consult the test history.
- **Patient**: This user is able to view your personal information and modify your information. Through the platform can this user consult the history of exams that were carried out.
- **Lab_operator**: This user is able to view your personal information, modify your information and those of the service provider. The platform allows you to record test results when authorized.

Figure-3 shows the start page, in which the user manual it can be consulted and log on to the system.

Figure-3. Web platform home.

Pressing the login button (*Iniciar sesión*) will display a form as in Figure-4, where the user id and password registered in the platform can be entered. To recover the password press the link recover password (*recuperar contraseña*).

Figure-4. Web platform login.

To authorize a test, the physician must select one of 10 options for the liver profile and add the authorization. The physician may remove the test after being authorized until it has been done. Figure 5 shows the screen which allows selecting the type o test.

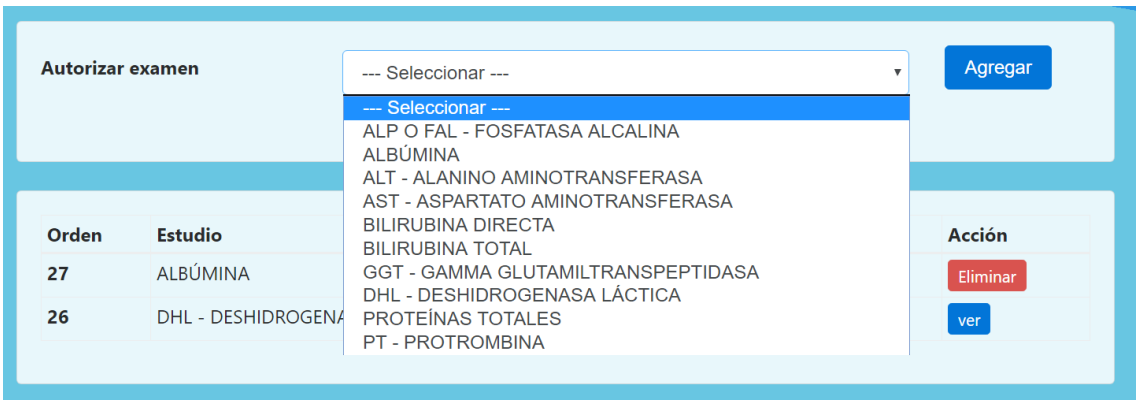

Figure-5. Type of liver profile test.

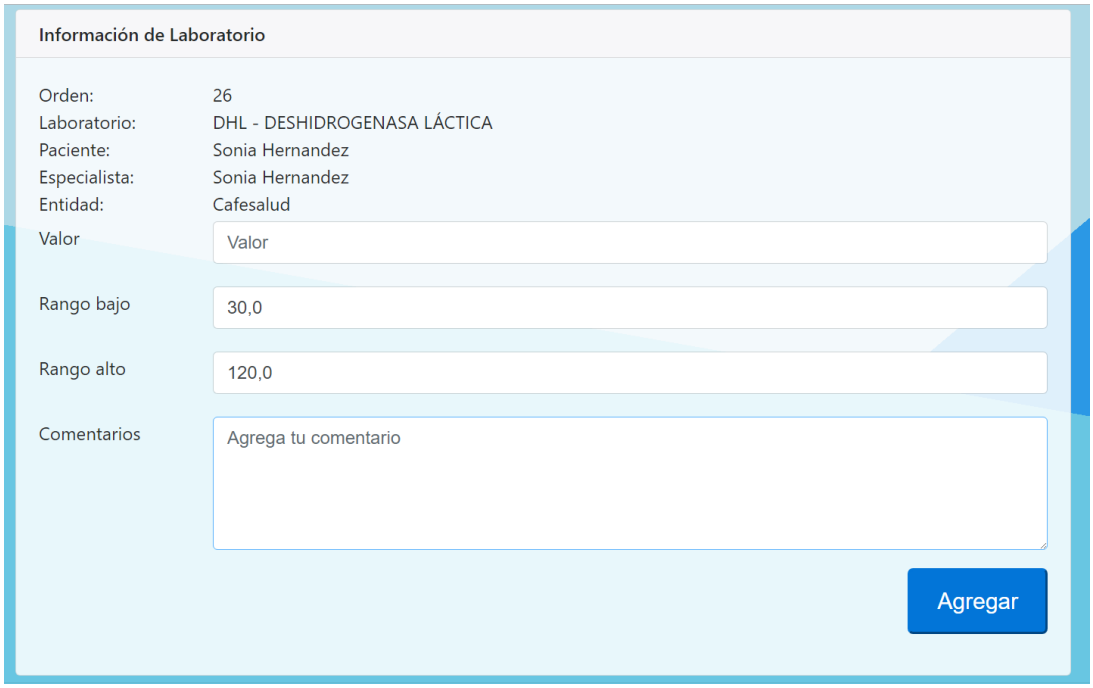

Figure-6. Liver profile test form.

After a test is authorized, the lab operator can access the order information and perform the test. A form like the one in Figure-6 must be filled in to take the exam.

Developments technologies

Tools with free software license were used for the development of the web project.

- Project developed using:

Spring Framework
Spring Tool Suite – version 3.8.4
Build Id: 201703310825
Java: 1.8.0_121

- Data base:

MySQL Workbench 6.3.8 build 1228 CE (64-bit) Community
Database port for MySQL: 3306

- Application server:

Apache Tomcat 8.5.14

Programming languages

HTML, CSS and JS: For view handling and script functions on the client side. HTML5 organizes parameters for HTML page structure tagging, CSS3 builds the page appearance for an interesting visual style and JS allows the construction of page functions on the client to avoid loading on the server.

JAVA SPRING: Spring is an enterprise open source framework for application development for the Java platform. With this, it is done the control of pages and development of the services of the application.

In addition, the following tools were used:

1. **Bootstrap v4.0.0-alpha.6**: This framework facilitates the web design adapatable to different devices through a responsive design.

2. **Font-Awesome**: This library contains compiled icons to give a better visual style to the pages.

3. **javax.mail version 1.4.7**: allows you to send mail messages from the server to the users. It is used to send an email to the user when requesting a password recovery.

4. **Gson version 2.6.2**: class library for handling JSON messages using java language.

5. **Mysql connector version 5.1.39**: library for controlling connections to the MySQL database from java.

RESULTS

The system allows patients, physicians, auxiliary staff and laboratory operators to enter information for platform interoperability. Each user role has different functions according to their profile. First, medical personnel must authorize patient examinations; these authorized examinations are awaited by laboratory operators. While the examination has not been performed, medical personnel may cancel the issued order. When the laboratory performs the examination enters the results and the information is available to be consulted by the staff or patients and thus the process is completed.

The platform allows authorizing 10 different exams of the liver profile as shown below.

- ALP OR ALKALINE FAL - PHOSPHATASE
- ALBUMINA
- ALT-ALANINE AMINOTRANSFERASA
- AST-ASPARTATO AMINOTRANSFERASA
- TOTAL BILIRUBIN
- GGT–GAMMA-GLUTAMIL TRANSPEPTIDASA
- DHL-DEHYDROGENASE LACTICS
- TOTAL PROTEINS
- PT - PROTROMBINA

Data query

Patients and medical staff will be able to see the test results by accessing the patient profile, which will show a table at the bottom of the page with the laboratories performed, as shown in the Figure. 7. To see the detailed order, just click on the View button, which will show descriptive data of the test performed. The test information contains in detail the type of laboratory, measurement range, measured value, unit of measurement and comments about the laboratory.

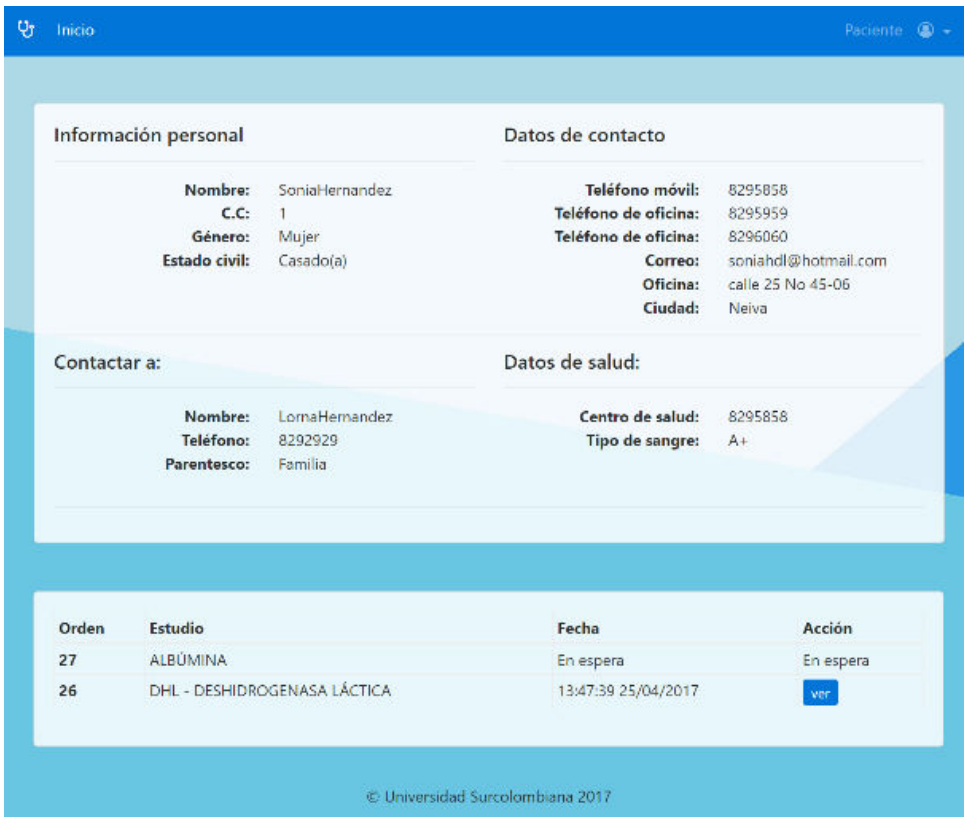

Figure-7. Patient profile.

Connection with other information systems

The information system is enabled to communicate with any other health information system that supports the HL7-FHIR standard and package the data using the JSON standard. This can be easily achieved by establishing channels between this system and any other that meets the above requirement and using Mirth Connect or a similar tool. Systems that pack their data using XML or other technologies can also be supported by making small adaptations.

Project file

The project can be consulted at: https://github.com/albecor/PerfilHepatico; where you can find the following files:

- Database / EERDatabase.mwb: Database model.
- Database / ScriptDatabase.sql: Script file of the database.
- Javadoc /: Contains the project API documentation
- User Manual /: Contains the user manual of the web application.
- Web Application / MedicalHepatic /: Application project file.
- Web Application / medicalHepatic.war: Application deployment file for the Tomcat server.

CONCLUSIONS

With the information system implemented, it is possible to optimize the communication between the agents involved in the authorization, realization and publication of the examinations for a patient in the Hospitals of Huila. This allows shorter test times and facilitates the work of medical staff to choose treatments that are appropriate to the specific condition of each patient. The use of information technologies should be intensified through the development of projects that solve many of the problems that afflict the Colombian health system. As has been shown, the Surcolombiana University's electronic engineering program can contribute to the development of the city, the department and in general the country.

The information system presented here ensures the integrity and readability of patient information and makes it possible for information to be available anywhere, regardless of the institution providing health services.

The execution of this project is expected to mark the way forward in the department and in the country in terms of the use of computer technologies as an immediate solution to many difficulties of the hospital centers. We hope to generate the basis for future projects that involve a full integration of the different areas of the hospital into robust, effective and reliable hospital information systems.

ACKNOWLEDGEMENTS

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REFERENCES

[1] Anstee QM, Jones DEJ. 2014. Liver and bilary tract disease. In: Walker BR, Colledge NR, Ralston SH, Penman ID, eds. Davidson's Principles and Practice of Medicine. 22nd ed. Philadelphia, PA: Elsevier; chap 23.

[2] Martin P. 2016. Approach to the patient with liver disease. In: Goldman L, Schafer AI, eds. Goldman's Cecil Medicine. 25th ed. Philadelphia, PA: Elsevier Saunders;chap 146.

[3] Pincus MR, Abraham NZ. 2017. Interpreting laboratory results. In: McPherson RA, Pincus MR, eds. Henry's Clinical Diagnosis and Management by Laboratory Methods. 23rd ed. Philadelphia, PA: Elsevier; chap 8.

[4] Pincus MR, Tierno PM, Gleeson E, Bowne WB, Bluth MH. 2017. Evaluation of liver function. In: McPherson RA, Pincus MR, eds. Henry's Clinical Diagnosis and Management by Laboratory Methods. 23rd ed. Philadelphia, PA: Elsevier; chap 21.

[5] FHIR community. 2017. FHIR V3.0.1. HL7 FHIR. Extraído de: https://www.hl7.org/fhir/

[6] Care2x. The open source hospital information system, 2013 Care2x Team. Extraído de: http://www.care2x.org/demo-page-online.

[7] e-Salud: El caso de México. Nancy Gertrudiz. Extraído de: http://cetes.medicina.ufmg.br/revista/index.php/rlat/article/viewFile/71/192

[8] Mirth Connect, Mozilla Licencia Pública (MPL) 1.1. Extraído de: https://www.mirth.com/

[9] MySQL, 2017, Oracle Corporation and/or its affiliates. Extraído de: https://www.mysql.com/