VOL. 15, NO. 7, APRIL 2020 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences
©2006-2020 Asian Research Publishing Network (ARPN). All rights reserved.
www.arpnjournals.com

LIPID PANEL TESTS: DESIGN AND IMPLEMENTATION OF AN INFORMATION SYSTEM FOR RESULTS RECORDING AND CONSULTING

Albeiro Cortes Cabezas[1], Cesar A. Perdomo Ch.[2] and Julián Rolando Camargo López.[2]
[1]Engineering Faculty, Universidad Surcolombiana, Neiva Huila., Colombia
[2]Engineering Faculty, Universidad Distrital Francisco José de Caldas, Bogotá D.C., Colombia
E-Mail: albecor@usco.edu.co

ABSTRACT

The main aim of this work was to create a healthcare information system that allows to medical and laboratory staff, authorize, register and consult data about the lipid panel tests made to the patients. This paper presents the design and implementation of an information system for the registration, organization and analysis of lipid panel tests results in the hospitals of the Department of Huila in Colombia according to the standards HL7-FHIR (Health Level 7 - Fast Healthcare Interoperability Resources). A result, an information system was designed and implemented using free software as java, html5, css3, etc. It was concluded that the proposed information system cans reduce the execution time and facilitate the work of the medical staff when lipid panel tests are performed.

Keywords: web services, HL7-FHIR, healthcare, information system, lipid panel.

1. INTRODUCTION

Cholesterol and triglycerides are lipids or fats important for cell health. However, they can be harmful when be accumulated in blood. Occasionally, they can cause arteries blockage and inflammation, which is a condition known as atherosclerosis. This can be cause of heart malfunction. Lipid panel tests allow to measure the amount of cholesterol and other fats present in the blood [1]. This panel tests helps to predict the risk of heart disease and stroke [2].

The lipid panel test measures the following facts:

- Total cholesterol
- Low density lipoprotein cholesterol (LDL) or “bad” cholesterol.
- High density lipoprotein (HDL) cholesterol or "good" cholesterol.
- Triglycerides, another type of fat which causes arteries hardening

It is advisable to perform this test panel if there is a family history of heart disease or stroke. It is also recommended in case of heart disease risk factors. These risk factors include [3]:

- High blood pressure (hypertension)
- Diabetes or prediabetes
- Overweight or obesity
- Habit smoking
- Workout lacking
- Diet with unhealthy foods
- Stress
- High total cholesterol level

The results of the lipid panel tests are measured in milligrams per deciliter (mg/dL). Below are the ranges of total cholesterol in adults [4].

- Normal: less than 200 mg/dL
- Maximum limit: from 200 to 239 mg/dL
- High: 240 mg/dL or more

These are the ranges of LDL cholesterol for adults:

- Optimum level: less than 100 mg/dL (this is the ideal level for people with diabetes or heart disease)
- Close to the optimal level: from 100 to 129 mg/dL
- Maximum limit: from 130 to 159 mg/dL
- High: 160 to 189 mg/dL
- Very high: 190 mg/dL or higher

The above-mentioned values are a general guideline, since the actual ideal levels depend on the number of heart disease risk factors that exist.

HDL cholesterol levels must be greater than 40 mg/dL. Actually, this type of fat is good because it reduces the risk of heart disease. The higher the value, the lower the risk. A level of 60 mg/dL or more is considered to be a level that protects against heart disease.

High triglyceride levels are associated with a higher risk of heart disease. Here are the ranges for adults. [5]

- Normal: less than 150 mg/dL
- Maximum limit: 150 to 199 mg/dL
- High: 200 to 499 mg/dL
- Very high: more than 500 mg/dL

Diabetes and cardiovascular diseases are a major public health problem, especially among older individuals. Risk factor assessment and in particular lipid screening has become increasingly important. Due to this several works related to lipid profile have been recently performed. For example, A. Lartey *et al.*, conducted a study on Lipid profile and dyslipidemia among school-age

©2006-2020 Asian Research Publishing Network (ARPN). All rights reserved.

children in urban Ghana. Dyslipidemia during childhood has been associated with higher risk of atherosclerosis later in life [6]. LW Sim, *et al*., in 2017 conducted a pilot study about the development of a clinical decision support system for diabetes [7]. MW MASSING et al., conducted an investigation to identify factors related to lipid testing among patients with diabetes who receive diabetes care from primary care physicians in USA [8]. M Carey, *et al.,* carried out an investigation to compare Point of Care - POC lipid profile measurements using a Cholestech LDX analyzer with a hospital reference laboratory at the Adelaide Meath incorporating the National Children's Hospital in Dublin [9]. In order to suggest broad guidelines about the testing of lipids, logistics and handling of specimens and methods of analysis and to outline reference limits for both high risk and low risk patients, C. Appleton, et al., made some recommendations for lipid testing and reporting by Australian pathology laboratories [10].

This article presents the design and implementation of an information system for registration, organization and analysis of lipid panel examinations results in the Huila Department Hospitals in Colombia. Using this Healthcare Information System - HIS, medical and laboratory staff can register, consult and authorize lipid panel tests. Data can be fed through local area network of the Hospital, 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, the most widespread worldwide standard for healthcare information systems [11]. Which guarantees 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 have better health; this is what justifies the need for more robust HISs for hospitals in Huila [12].

2. MATERIALS AND METHODS

Figure-1 shows the block diagram of the information system. The information system includes a database schema implemented in MySQL [13] where all data information is stored, a web server that delivers the pages and allows to control the platform, the web client that requests the connection through the web server and optionally include an interoperability tool between information systems, such as MirthConnect [14], to achieve integration with other information systems.

The recommendations of the HL7-FHIR standard for delivery of medical information were considered in the design of the information system, which guarantees interoperability of this information system with other systems through the connection protocols of the aforementioned standard. HL7-FHIR is a standard that describes the resources, data formats and elements for the electronic health record exchange (EHR). The standard was created by the international health standards organization HL7.

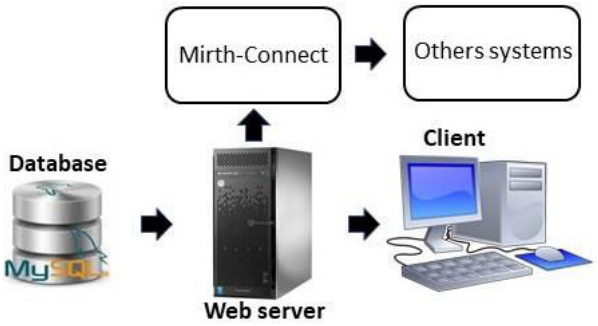

Figure-1. Blocks diagram of the information system.

2.1 Database

MySQL is the most popular open source database, it's a reliable and secure option. In addition, it has features such as high scalability, easy handling and high performance among others, making it the ideal option for the needs of this information system. Figure-2 shows the database design used.

©2006-2020 Asian Research Publishing Network (ARPN). All rights reserved.

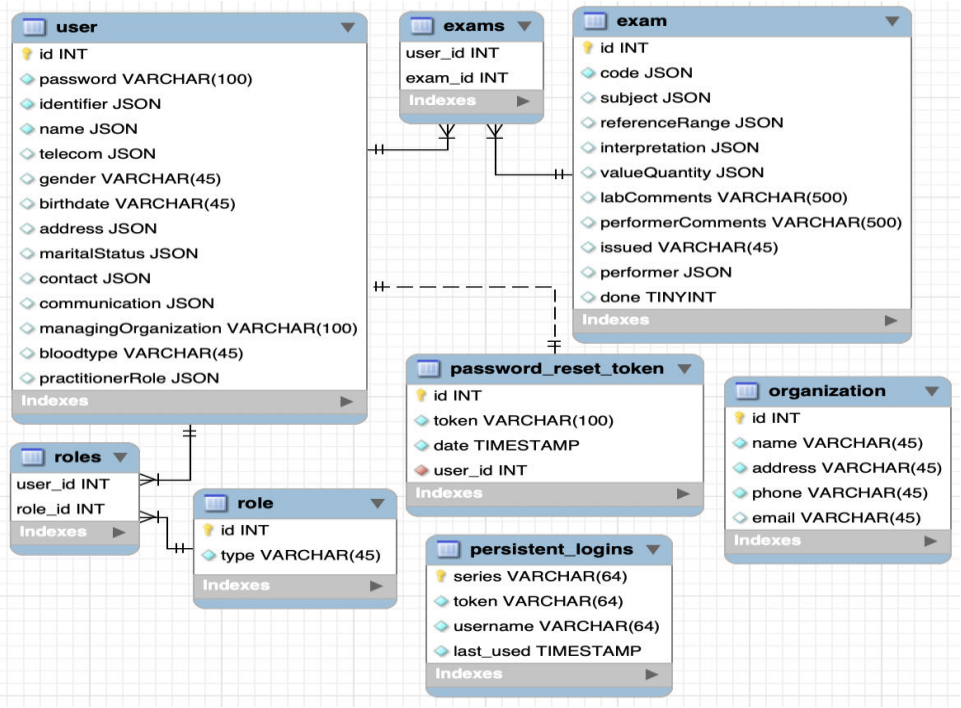

Figure-2. Database design.

For the user and exam tables, fields are constructed in JSON format as established by the HL7 standard. Next, a brief description of each table is presented:

- **user:** This table stores information corresponding to the platform users.
- **roles:** This table contains the type of role of each individual user.
- **role:** This table contains the types of user roles used in the platform. The types of user roles in the platform are shown below:

- **ADMIN:** role for the administrator.
- **PATIENT:** role for patient.
- **PERSONNEL:** role for staff.
- **LAB:** role for laboratory workers.

- **exams:** Many to many relationship table between the user table and the exam table that contains the user's exams.
- **exam:** This table stores information corresponding to the lipid panel tests.
- **organization:** This table stores information about the service provider entity.
- **persisten_logins:** This table stores information about sessions that are remembered in the browser.

2.2 Web platform

The web platform allows users to manage the registered information in the system and perform several operations. The platform allows also four different types of users or profiles, which are defined below:

- **Administrator:** This type of users is in charge of registering, modifying or eliminating other users of the platform. This user has full control of the platform.
- **Staff:** This type of users can view and update their profile information, (but do not change the type of user). He also has access to the patient's data and cans authorize exams and consults the result records.
- **Patient:** This type of users can see and update their profile information, (but do not change the type of user). The patient user cans consult the results history of the of the examinations that were carried out.
- **Lab-operator:** This type of users can view and update their profile information, (but do not change the type of user) and those of the entity that provides the laboratory service. The Lab-operator can register the results obtained during lipid panel tests upon they have been carried out.

The platform has support for English and Spanish languages. Figure-3 shows the starting view of the platform

©2006-2020 Asian Research Publishing Network (ARPN). All rights reserved.

Figure-3. Starting view of the platform.

Users can access to the platform using their personal identification number and a password. The platform can remember user sessions and recover its password if you do not remember it, as shown in Figure-4.

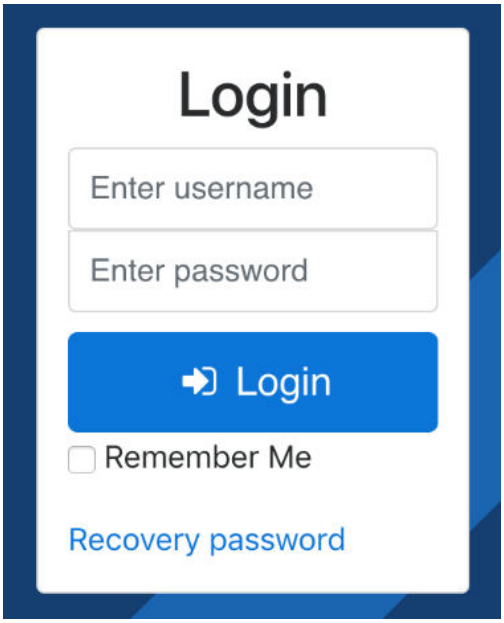

Figure-4. Login page.

Each user can update their personal information on the platform except their identification number and user role. Only the administrator user can change a user's identification number and user role.

Physicians can authorize different lipid panel exams using the patient's identification number. When an examination is authorized, the physician can cancel this authorization as long as it has not been done by the lab-operator. Figure-5 shows the view from where the physicians can authorize one or more of the tests included in the lipid panel for a particular patient.

©2006-2020 Asian Research Publishing Network (ARPN). All rights reserved.

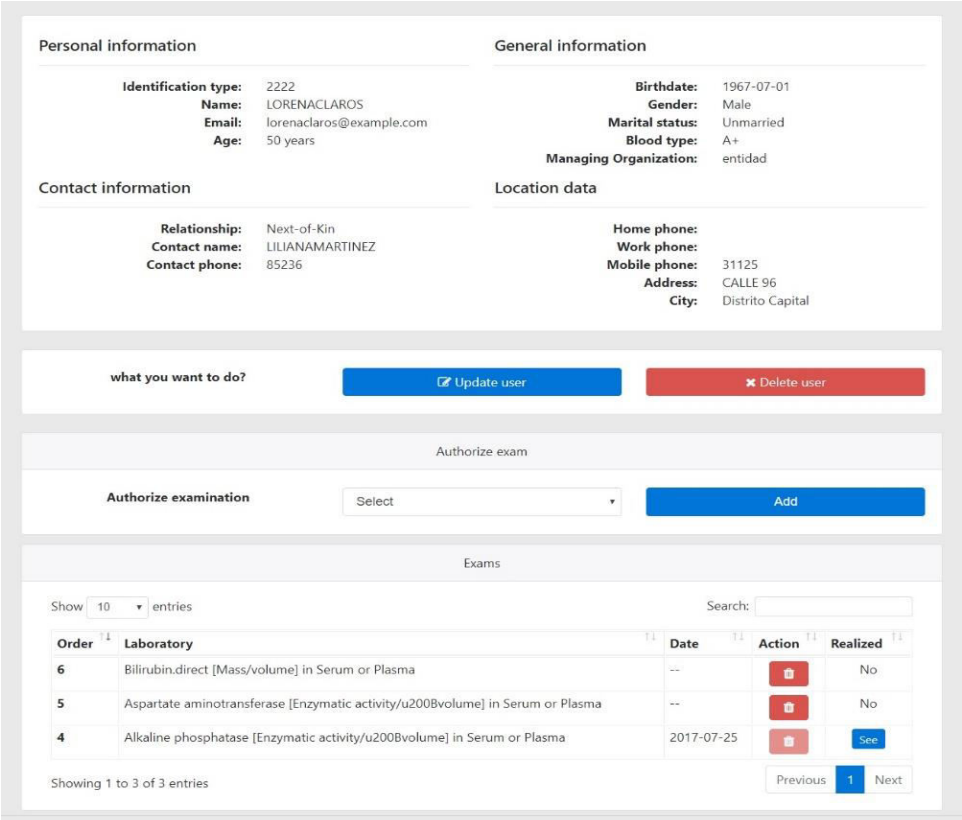

Figure-5. Page for tests authorization.

Tests performed by the laboratory can be quantitative if a variable is measured or descriptive if only the presence of a compound in the sample needs to be determined. Figure-6 shows the form that allows lab-operators to record tests results.

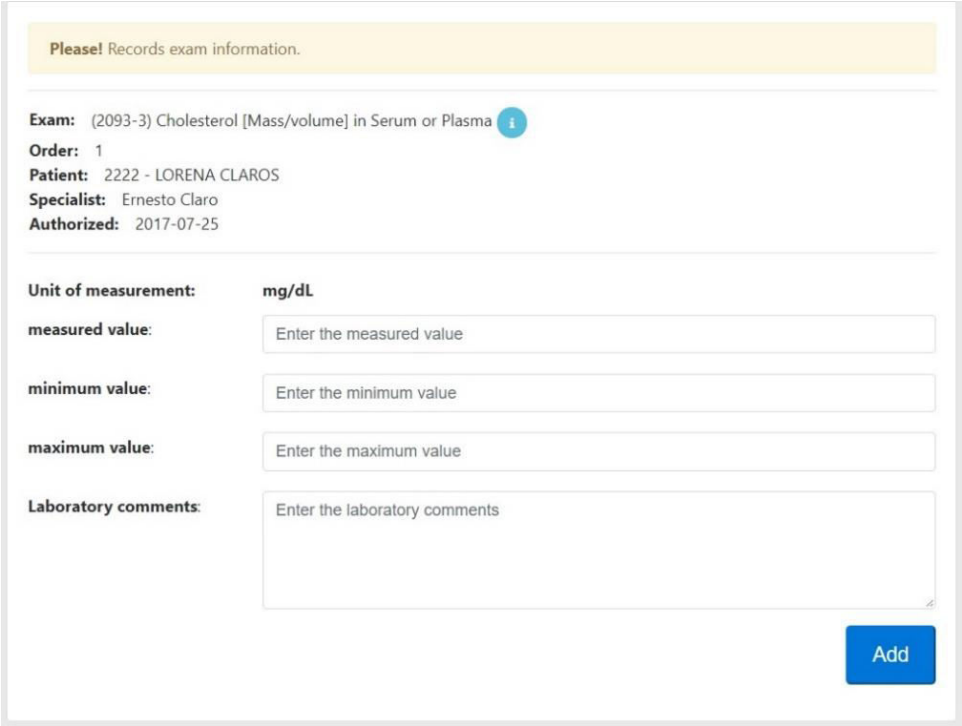

Figure-6. Test results record form.

©2006-2020 Asian Research Publishing Network (ARPN). All rights reserved.

2.3 Technologies used in platform development

For development of the web platform, tools with free software license were used. Below are the tools used. Project developed in:

- Spring Tool Suite
- Version: 3.8.4.RELEASE
- Build Id: 201703310825
- Platform: Eclipse Neon.3 (4.6.3)
- JavaSE-1.8(jre1.8.0_121)

Database:

- MySQL Workbench 6.3.8 build 1228 CE (64 bits) Community
- Port for MySQL database: 3306

Web server:

- Apache Tomcat 8.5.14

2.4 Programming languages

HTML5, CSS and JS: These programming languages were used for views management and script functions in the client. HTML5 organizes parameters for structure labeling of the HTML page, CSS3 builds the appearance of the page for an elegant visual style and JS allows the construction of page functions in the client to avoid overload in the server.

JAVA spring: Spring is a framework for the development of applications and control inversion container, open source for the Java platform. With this, the pages control and development of the services for the application is carried out.

In addition, the following tools were used:

- **Bootstrap v4.0.0-alpha.6:** Framework that facilitates an adaptable web design to different devices using responsive design.
- **Font Awesome:** This library contains a compilation of icons to give the pages more visual style.
- **javax.mail version 1.4.7:** It allows the mail messages sending from the server to the users. It is used to send an email to the user when requesting a password recovery.
- **Mysql connector version 5.1.39:** Library for the control of connections to the MySQL database from java.

3. RESULTS

Each user role has different functions according to its type. First, the physicians must authorize the tests to the patient. The authorized tests remain waiting to be performed by the lab-operators. While the test has not been done, the physicians can cancel the authorization issued. After the lab-operator performs the test, records the results and the information is available to be consulted by physicians or patients and the process is completed.

The platform allows to authorize 7 different tests of the lipid panel, which are shown below.

a) Cholesterol [Mass/volume] in Serum or Plasma
b) Triglyceride [Mass/volume] in Serum or Plasma
c) Cholesterol in HDL [Mass/volume] in Serum or Plasma
d) Cholesterol in LDL [Mass/volume] in Serum or Plasma by Direct assay
e) Cholesterol in VLDL [Mass/volume] in Serum or Plasma by calculation
f) Cholesterol in LDL/Cholesterol in HDL [Mass Ratio] in Serum or Plasma
g) Cholesterol-total/Cholesterol in HDL [Mass Ratio] in Serum or Plasma

3.1 Query results

Patients and physicians will be able to see the results of the exams by accessing each patient's profile. When the physician accesses the patient's profile, you can see a table at the end of the page with the laboratories performed. Figure-7 shows the list of authorized tests for a patient. There it cans be seen some pending tests and others already done.

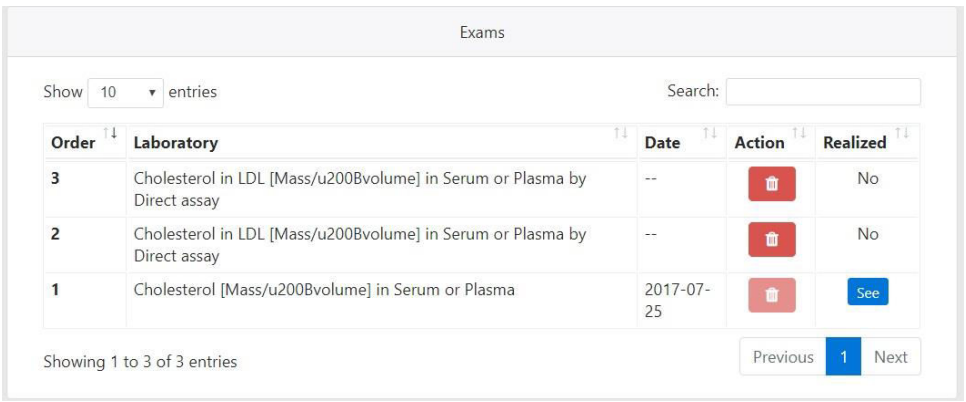

Figure-7. List of tests performed and to be performed.

In Figure-8, you can see the detailed result of a test performed. In addition to numerical data, a description or evaluation of the results obtained can be observed. The Figure specifies the type of test, the reference range, the

©2006-2020 Asian Research Publishing Network (ARPN). All rights reserved.

measured value, the unit of measurement and the comments on the result. For the non-quantitative tests, the comments of the lab-operator and the physician about the presence of the compound are shown.

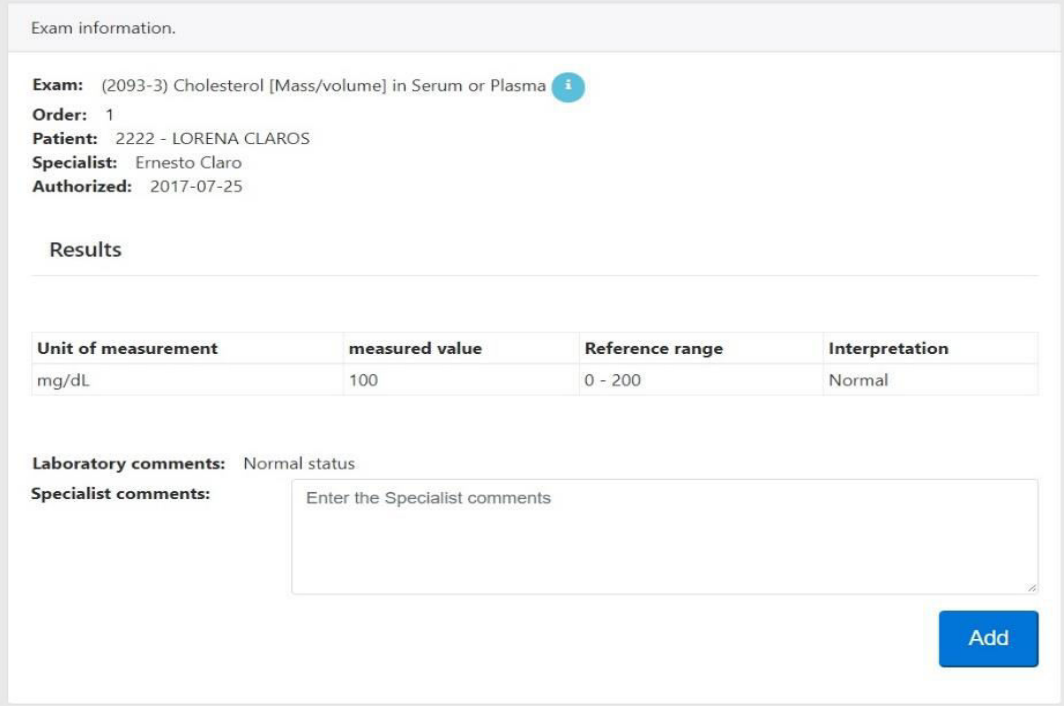

Figure-8. List of tests.

3.2 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 requirement mentioned above and using Mirth Connect or a similar tool. Systems that package their data using XML or other technologies can also be supported by making small adaptations.

3.3 Project file

The project can be consulted at the following address: https://github.com/albecor/Medical_Lipid, where you can find the following files:

- **Database/EER Database.mwb:** Database model.
- **Database/Script Database.sql:** Database script.
- **Javadoc/:** Contains the project API documentation.
- **Research Project/:** Contains the project research information file.
- **User Manual/:** Contains the user manual of the web application.
- **Web Application/medical_lipid/:** Project file of the web application.
- **Web Application/medical_lipid.war:** Application deployment file for the Tomcat server.

4. CONCLUSIONS

With the information system implemented, the communication between the agents involved in the authorization, realization and publication of the results of the lipid panel tests for a patient in the Huila hospitals is reduced, reducing the execution time and facilitating the work of the medical staff when choosing treatments according to the specific health condition of each patient. The use of information technologies should be intensified, through the development of projects that provide solutions to many of the problems that afflict the Colombian health system. As has been demonstrated, the Electronic Engineering Program of the Surcolombiana University can contribute to the development of the quality of life of the patients of the city, the department and in general of the country.

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

It is expected that the execution of this project will 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 with this to generate the bases for future projects that involve a total integration of the different areas of the hospital in robust, effective and reliable hospital information systems.

5. ACKNOWLEDGMENTS

This work was funded in part by the Surcolombiana and Distrital University in Colombia.

©2006-2020 Asian Research Publishing Network (ARPN). All rights reserved.

REFERENCES

[1] Care First, Panel de lípidos. 2015. [Internet]. August 27. [Cited 2018 September 26]. Available from: http://carefirst.staywellsolutionsonline.com/RelatedItems/167,lipid_panel_es

[2] Patrick J. Twomey, Damian Griffin, William Tormey, Vivion Crowley, and Gerard Boran. 2017. Recommendations for the testing and reporting of lipids in clinical diagnostic laboratories within the Republic of Ireland. National Laboratory Handbook. [Internet]. 2017 December 06. [Cited 2018 November 05]. Available from: http://www.beaumont.ie/media/Laboratory_Testing_for_Lipids1.pdf

[3] Colesterol, Toda la informacion sobre el cholesterol. [Internet]. 2017 March 25. [Cited 2018 October 02]. Available from: http://colesterol.org.es/nivel-normal

[4] Deborah Weatherspoon. The Recommended Cholesterol Levels by Age. [Internet]. 2018 September 28. [Cited 2018 November 04]. Available from: https://www.healthline.com/health/high-cholesterol/levels-by-age

[5] James Beckerman. 2016. High Triglycerides: What You Need to Know. [Internet]. 2016 October 06. [Cited 2018 November 04]. Available from: https://www.webmd.com/cholesterol-management/high-triglycerides-what-you-need-to-know#1

[6] Anna Lartey, Grace S. Marquis, Richmond Aryeetey and Helena Nti. 2018. Lipid profile and dyslipidemia among school-age children in urban Ghana. BMC Public Health.

[7] Sim L. L. W., Ban K. H. K., Tan T. W, Sethi S. K., Loh T. P. 2017. Development of a clinical decision support system for diabetes care: A pilot study. PLoS ONE 12(2): e0173021. doi:10.1371/journal.

[8] Mark W. Massing, Nancy S. Henley, Lori Carter-Edwards, Anna P. Schenck, Ross J. Simpson, JR. 2003. Lipid Testing Among Patients with Diabetes Who Receive Diabetes Care from Primary Care Physicians. Diabetes Care. 26(5).

[9] M. Carey, C. Markham, P. Gaffney, G. Boran and V. Maher. 2006. Validation of a point of care lipid analyser using a hospital based reference laboratory. Irish Journal of Medical Science · December.

[10] Charles Appleton, Grahame Caldwell, Alan McNeil, Matthew Meerkin, Ken Sikaris, David Sullivan, David Thomas, David Tognarini. 2007. Recommendations for Lipid Testing and Reporting by Australian Pathology Laboratories. Clin Biochem Rev. Vol. 28 May.

[11] FHIR community. [Internet]. 2017 April 09. [Cited 2018 October 04]. Available from: https://www.hl7.org/fhir/

[12] World Health Organization. Health statistics and information systems - World Health Statistics 2018: Monitoring health for the SDGs. [Internet]. 2018 September 27. [Cited 2018 November 04]. Available from: http://www.who.int/healthinfo/en/

[13] MySQL, Oracle Corporation and/or its affiliates. [Internet]. 2018. [Cited 2018 October 04]. Available from: https://www.mysql.com/

[14] Mirth Connect. [Internet]. 2018 May 30. [Cited 2018 October 04]. Available from: https://www.mirth.com/