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Diabetes tracking panel: an on-line information system to registration and management

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Article Info

ABSTRACT

Online hospital information systems enable health care providers to ensure information. Although nowadays there are great technological advances; in Colombia, the impact on the health sector has been low. As a result, there is an increasing deficiency in cities with less access to new technologies. Therefore, it is necessary for the government and health care providers to join efforts to expand the use of information technologies in the health area to improve the overall quality of the service provided. Therefore, this project introduces diabetes tracking panel tests system to improve the management process. The development system is based on several Open-Source platforms, such as MySQL, among others. Finally, we found that implemented system can reduce the time management of diabetes tests by the staff medical and assistance care personal.

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1. INTRODUCTION

Over the world, diabetes disease is produced because of too little insulin, insulin resistance or both [1]–[4]. On the other hand, diabetes disease is a process where meal is converted and used for humans to produce energy. In addition, meal is consumed, and several things happen that are shown as: i) Glucose into the circulation; that is a source of human body energy, and ii) Pancreas creates insulin, then is introduced into circulation of muscle, fat, and liver cells, where it can be stored or used for energy.

On the other hand, a human with diabetes has high levels blood sugar due to three reasons for this: i) the pancreas does not produce enough insulin, ii) cells do not respond normally to insulin, iii) both above reasons [5]–[8]. Thus, type 1 diabetes, appears at any age, even is more often diagnosed in children, adolescents, or young adults. This occur at any age; however, is most detected during the youth. Type 2 is usually in adult; because of, high rates of obesity that is a factor of diabetes disease.

Symptoms of diabetes

In general, some symptoms of diabetes, begin when a person has high blood sugar, they may have a variety of symptoms, for example: blurred vision, excessive thirst, fatigue, and among. Also, type 2 diabetes develops slowly; and some people with high blood sugar levels have no symptoms. In addition, following are the main features that are part of the diagnosis of diabetes as a disease in humans.

Tests and examinations

A urine test may show high levels of blood sugar, but a urine test alone does not diagnose diabetes (200 mg/dl (11.1 mmol/L); thus, to diagnosis, one or more of the following tests should be done.

Blood tests

Fasting blood glucose, allows diagnosis if the fasting glucose level is greater than 126 mg/dl (7.0 mmol/L) on two different tests. Levels between 100 and 126 mg/dl (5.5 and 7.0 mmol/L) are called impaired fasting glucose or pre-diabetes.

In addition, the diabetes is a disease with which clinical aspects are related to cardiovascular and cerebral accidents [9], [10], and today it is associated with mortality generated by COVID-19 [11], [12]. Therefore, it is important to prevent, diagnose and treat diabetes [13], [14]. In relation to the above, several solutions have been developed based on technological solutions, which address different aspects of the diagnosis and treatment of diabetes. In [15], the authors created something they call "digital twin", which allows to personalize food consumption in people with genetic predisposition to diabetes; that based on neural networks can create a food model for each person. Also, in [16] a digital platform based on "self-management" is introduced, which helps patients with diabetes to monitor the disease. The platform has been co-designed and co-developed jointly by patients and physicians, based on the principles of design science (DSRM).

Moreover, authors have used disease prediction and classification techniques for diabetes. For example, researchers presented a paper that has mixed two learning algorithms (ada boost and random forest) for feature selection, which used the "decision tree" classifier to classify healthy and diabetic people. Also, they performed a statistical analysis that showed that the proposed method effectively detected diabetes and can be implemented in e-healthcare environments [17]. Likewise, in [18] introduce an integrated approach called Farthest First (FF) clustering. This work used a dataset of 768 diabetic patient samples taken from Pima Indians Dataset; where, the results showed that the proposed integrated approach achieves a classification accuracy of 99.4% to predict DM. Finally, there are other research using data mining and machine learning techniques to do classification and prediction of diabetes disease [19]–[21].

Finally, the different efforts of the research community to design and implement technological solutions to improve the processes to prevent, diagnose, and treat diabetes are evident. However, many solutions are tailor-made for specific contexts; therefore, it is necessary to have access to a scalable, multiplatform, and customizable tool that can be implemented in any context of the clinical area for the disease.

In the current work we introduce the building process of an information system to management the diabetes test results Huila, Colombia. Additionally, this research is focusing to implement a Hospital Information System (HIS) that collect fully information of patients, medical and laboratory employees, who can access and operate the systems. Also, the system can be used on remote computer or devices by Internet.

2.   RESEARCH METHOD

Two stages that were completed to develop the SIH are presented below. First, the elements that were used for the overall design of the platform are presented. Second, the development technologies used are introduced, highlighting the characteristics of each tool used.

2.1. Platform general design

Initially, we introduce the general design of to explain the proposed system, see Figure 1. Thus, the implemented system is based on MySQL database where is controlled the platform, and users request the services database; additionally, web-clients request services from any devices with internet connection. Therefore, in these stages of development process, the database was elaborated using parameters and files to operate as well as possible and reach the best performance; after the web service controlling of the web pages through the server. This solution use health level 7-fast healthcare interoperability resources (HL7-FHIR) standard for universal standardization of health information, due to platforms as MirthConnet use database through itself standard communications.

2.1.1. The fast healthcare interoperability resources

HL7-FHIR allows that resources, database, components of electronic health records (EHR) exchange. Thus, HL7-FHIR is useful interoperability between different health platforms and is easy to keep information to several platforms and devices compatibility, such as personal computers, tablets, smartphones, and to allow to developers the implementation the medical systems that can be unified with previous solutions. Additionally, the solution is web-based platform, such as RESTful, HTML, Cascading Style Sheets (CSS), and to data representation JavaScript Object Notation, (JSON); finally, OAuth for authorization [22].

However, the integration with platforms that use technology to display the data is accomplished through a tool HIS (like MirthConnect). Additionally, this article is a piece of a big project where main goal is integrated different health information systems in the Huila Department. This work is a phase of project in the Department of Huila, that aims to develop a fully health system, to allows integrate several health currently platforms [23], [24].
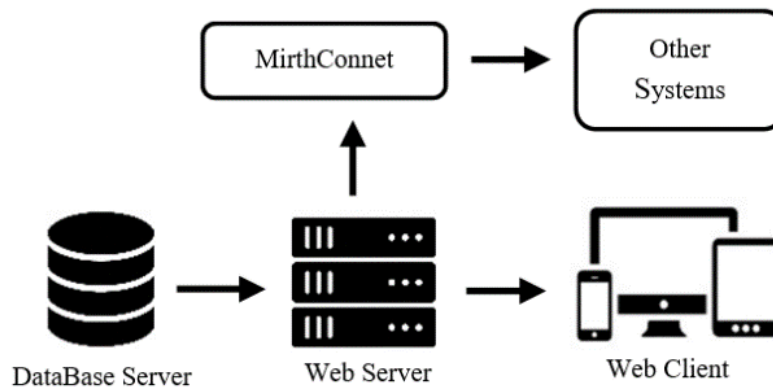
Figure 1. Interoperability system diagram

2.2. Development technologies
To implement this system, we used several Open-source tools of the OpenSource type (like JAVA) and based-on the SIH standard.

2.2.1. Development environment
To programming the implemented system we used technologies, which as, **Spring Tool Suite**: version: 3.8.4, with Eclipse Neon.3, and JavaSE-1.8. **Database**: MySQL Workbench 6.3, and Apache Tomcat 8.5.14.

2.2.2. Development languages
To develop this solution, we used several tools, such as: *HTML5*, *JAVA SPRING*, *Font Awesome*, *MySQL connector version 5.1.39, CSS3, JS*, and *JAVA SPRING*.

3. RESULTS AND DISCUSSION
3.1. Database engine
The development of this solution was based on different tools and platforms, which are presented in subsection. MySQL DataBase system was used in our recent works in [25], [26]. Additionally, this platform has advantages such as scalability, useful, and throughput.

First, we introduce the table that stores user data. As well, a many sessions tables allow store information for the diabetes tracking panel tests. Consequently, the database diagram describe above can be designed, see Figure 2. On the other hand, to build the *User* and *Exam* tables we used JSON format based on HL7. Thus, the complete representation of implemented tables, such as i) *user*: stores the platform user' data, ii) *roles*: table that is relationships with many tables.
Role: containing user roles, and its fields are:
a. *ADMIN*: administrator role
b. *PATIENT*: patient role
c. PERSONAL: staff role.
d. LAB: lab technician role
exams: containing the user's exams.
Exam: stores information about the medical tests of the liver profile.
Organization: table stored by the service provider.
Persisten_logins: stores and remember the metadata session log.
According to the HL7 standard to fully describe the exam and its result the ReferenceRange, Interpretation and ValeQuantity fields should be included in the exam table. Therefore, the following is how it was implemented in this solution:
- *ReferenceRange*: defines the reference range of the variable, this field is represented by the following variables. For the minimum value of the range: low-code: reference code of the variable, low-unit: unit of measure, low-value: measurement value, low-system: reference information of the variable. Also, for the maximum value of the range: high-code: variable reference code, high-unit: unit of measure, high-value: measurement value, high-system: reference information of the variable.
- *Interpretation*: interpretation of the measured variable, this field is represented by the following
- *Variables*: coding-code: reference code of the measurement status, coding-system: reference information of the variable, coding- display: measurement status description.

- *ValeQuantity*: defines the measured value of the test variable. This field is represented by the following variables: code: variable reference code, unit: measurement unit, value: measured value of the variable, system: reference information of the variable.
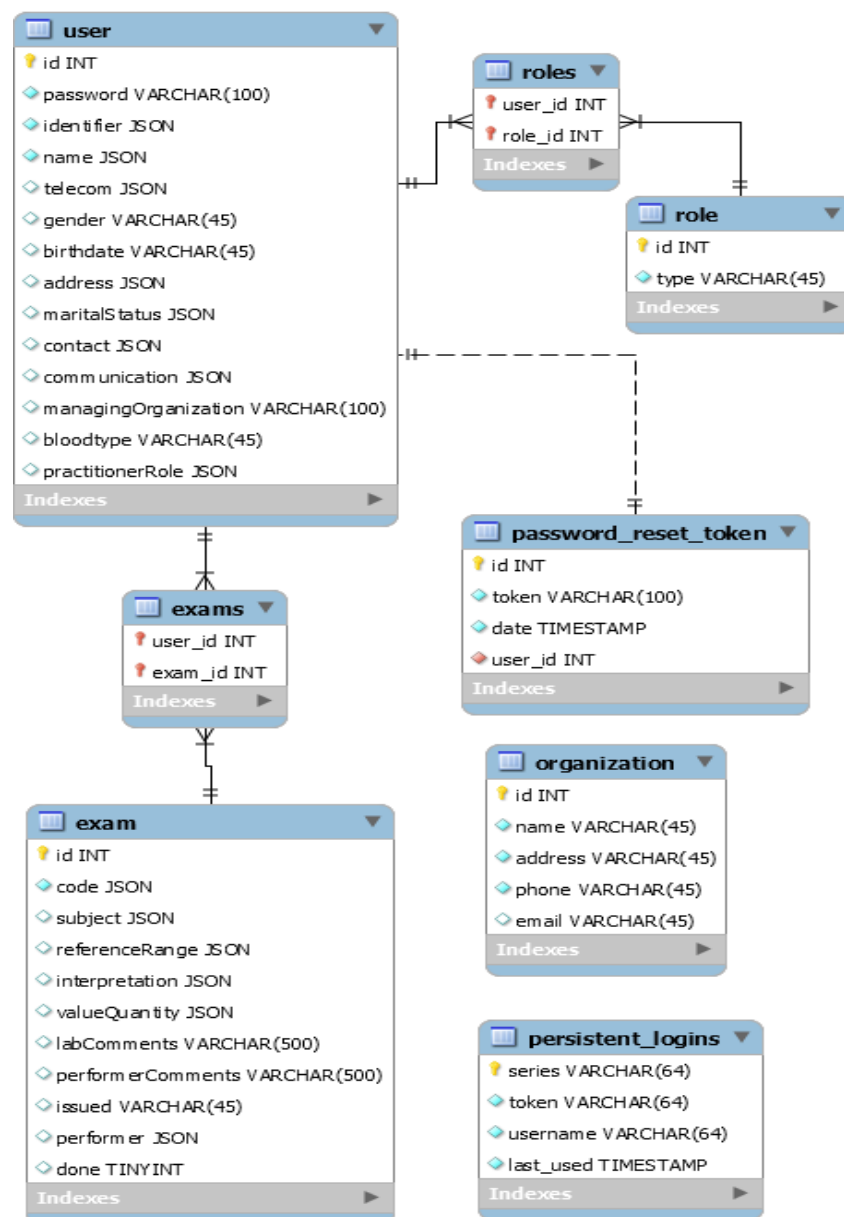

Figure 2. Database diagram

3.2. Web platform

This environment allows the users execute options to manage the stored data in the platform. A representation of website view screen can see in Figure 3. This screen allow login to different types of users:
- *Administrator*: it is recorded via website, and has function to modify, or deleting other users.
- *Personal*: can display basic information and modify information, and check patient's data, that allows manage histories and test results of the diabetes tracking panel.
- *Patient*: can see and modify its own personal data. Additionally, allows to check the *history* exams.
- *Lab technician*: can see and modify personal data, and information provided for the laboratory services. Additionally, allows record the patient data got during the medical treatment.
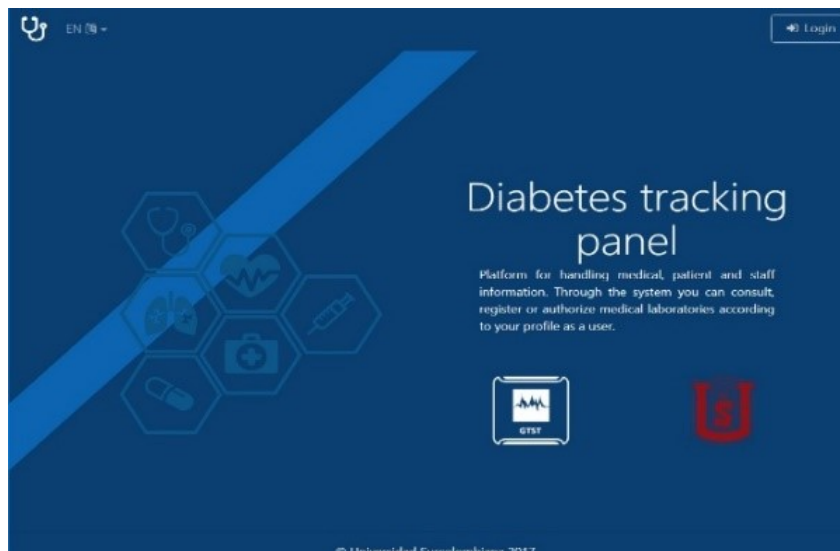
Figure 3. Website view

In addition, the login system allows users access using ID and password; Thus, can save the credentials login to next access, see Figure 4. Finally, the platform can be setup in English and Spanish languages.

Users can do many functions that depend on kind of profile; thus, the Figure 5 introduces the system instance where, *Administrators* can edit any user profile, and *medical staff* profiles can access to the patient data and approve exams, *Patients* can check personal data and process exams. Finally, *Labs* is managed by laboratories and authorized medical staff.
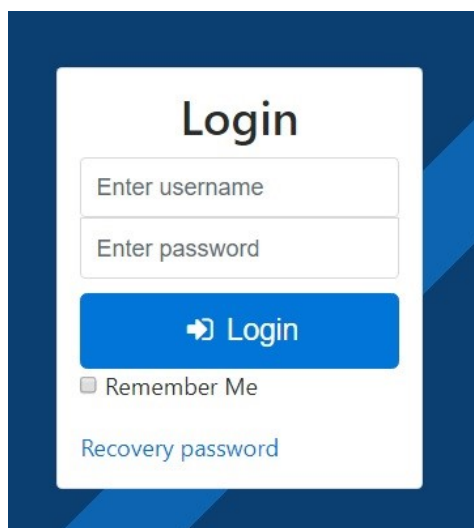
Figure 4. Login screen view
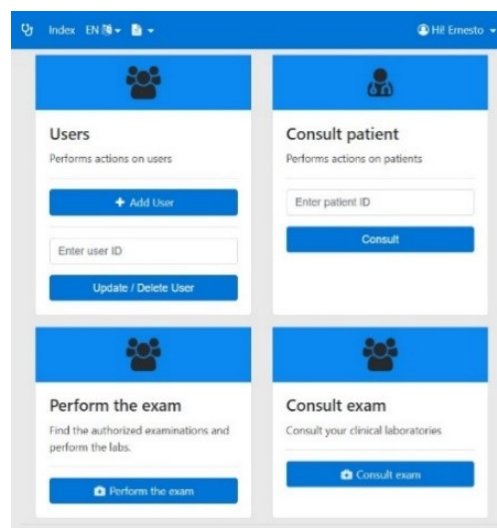
Figure 5. Website user profile

Likewise, the user updates its personal data. Consequently, must use administrator profile when needs change data profile. In addition, Figure 6 contains a view of information stored for the user. Finally, the main functions of administrator are updated the ID number and user roles. In addition, a doctor profile can authorize and review different tests. Then, after that test is authorized, doctor can retire the authorization, see Figures 7.

Consequently, tests are realized by the laboratory and can be quantitative or descriptive when the presence of the compound in the sample is determined, see Figures 8 and 9. In general, the built HIS allows any type of user with access to the reporting system to enter data for the platform successful performance.

Figure 6. User form

Figure 7. General user information

In addition, the *User* profile has different options: thus, the medical staff authorize patient's tests. Therefore, if the test has not performed, the order exam can be cancelled, see Figure 8. However, when the laboratory performs the exam; the results are added into the system for consult by any user. In this way, system allows addressing high amount of test of diabetes tracking panel (10, max value), and they are shown as:

a.   Glucose
b.   Glucose–lab
c.   Hours after meal

d.   Haemoglobin, total in blood
e.   Glucose mean value in blood
f.   Microalbumin [mass/volume] in urine
g.   Ketones in urine by test strip
h.   Glucose in urine by test strip
i.   Calorie (24 hours)
j.   Date of last eye exam

Figure 8. Quantitative test form

Figure 9. Patient information results

Additionally, another achievement of this solution are the data queries, due to it help the patients and medical personal to see the tests of each patient results. As a result, Figure 10, shows the laboratory order finished, that describes of exams results, and displays the kind of laboratories, range of measurement, values, and among; Finally, a brief of the presence of a chemical compound finding are shown.

Exam information.

Exam: (5792-7) Glucose [Mass/volume] in Urine by Test strip ⓘ
Order: 1
Patient: 2222 - LORENA CLAROS
Specialist: Ernesto Claro
Authorized: 2017-07-26

Results

Unit of measurement	measured value	Reference range	Interpretation
mg/dL	50	74 - 106	Low

Specialist comments: Enter the Specialist comments

Add

Figure 10. Test information

In addition, the developed HIS connection with other information systems is not included in this solution, then after the finished development, begin operation, and able to connect to other HIS that be HL7-FHIR standard compatible. This connection can be reached establishing pipelines between this HIS and any other systems. Thus, systems that use XML package or other platforms can be integrated with minor changes. In addition, to access to special information of SIH, as the project code and full directory structure [27].

4. CONCLUSIONS

This work presents a complete system that allows improving the processes that constitute the main activity of the medical staff that integrates the health system. Thus, the most important processes that have been improved are authorization, execution, and publication of a patient's tests, which allows reducing the execution time of the complete process of administration of test results for the diagnosis of Diabetes in the department of Huila. Consequently, the implemented system facilitates the activities of the medical personal in choosing the appropriate therapies for each patient's condition.

On the other hand, the solution presented in this work guarantees the integrity, readability and accessibility of patient data and makes it possible available 24 hours a day for any healthcare entity, since the system allows access from any device connected to the Internet. Additionally, the system can be integrated into any healthcare system due to the technologies used for the development of the solution. Consequently, it is recommended to increase investment in new information and communication technologies; therefore, Colombia must implement strategies that provide resources to public and private organizations to develop projects that provide solutions that Colombian health system needs.

Finally, according to the World Health Organization (WHO), when medical personnel have updated information in real time, appropriate decisions are made; thus, users have a better health service; which supports the requirement of a robust HIS for Colombian hospitals.

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