VOL. 13, NO. 19, OCTOBER 2018 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

DESIGN OF AN INFORMATION SYSTEM FOR RECORDING AND MONITORING BLOOD PRESSURE

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ABSTRACT

Over the years, the rate of people with blood pressure problems, whether hypertension, hypotension or heart failure, has increased drastically. This is due to the lifestyle that society has adopted, since it has left very important aspects for health such as a healthy diet and exercise. Over time this lifestyle has triggered a significant degradation of health, especially in the cardiovascular aspect. Which can be avoided with a better lifestyle and with monitoring and control of our blood pressure to perform a constant analysis of the behavior of this variable. That is why, through this work, the implementation of a blood pressure monitoring and recording system based on the FIHR standard of the HL7 family has been proposed. The main objective is to provide patients with a mobile application that allows them to adequately control their blood pressure and their records, so that timely preventive measures can be taken by analyzing these records.

Keywords: hospital information system, blood pressure, HL7-FHIR.

INTRODUCTION

With the passage of time cardiovascular diseases (CVD) have shown a rapid increase, to the point of becoming the leading cause of death in the world. For 2008, noncommunicable diseases (NCDs) caused 63% of the total deaths recorded in the world; these figures are estimated to increase by around 15% (44 million) by 2020. Within the group of NCDs, cardiovascular diseases represent the main cause of death. In Colombia, cardiovascular disease is the leading cause of death along with diabetes; Figure-1 shows the NCD mortality rates in the country. It is estimated that 1 in 3 people suffer from problems related to blood pressure, affecting approximately 80% of the population over 60 years, the other 20% is reflected in various ages. Hypertension is affecting younger and younger people, 34% of men and 25% of women older than 25 are affected [1]. Intervention by decision makers is required with actions in public policies that promote a culture of physical activity, healthy nutritional habits and the control of risk factors [2].

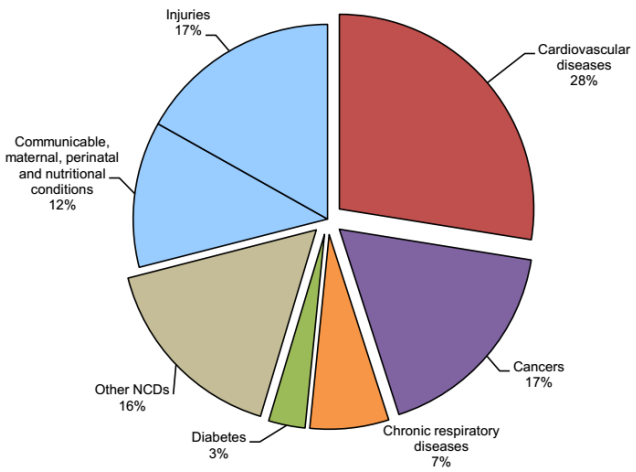

Figure-1. Morbidity rates of non-communicable diseases in Colombia [11].

If we focus particularly on diseases directly related to blood pressure we can say that they are silent; that is, they do not present symptoms until the condition is already at an advanced stage. To avoid this, it is necessary to keep a constant and orderly control of blood pressure, in order to have a history that describes the behavior and evolution of said variable. Continuous monitoring of blood pressure can allow acute and chronic complications such as hypertension and arterial hypotension to be detected and prevented early, as well as adjusting the patient's lifestyle if necessary to guarantee good health [3].

Taking into account the above, we want to provide patients with a tool that allows them to carry out this control in order to independently and orderly manage their blood pressure records and thus, prevent future diseases, if they do not suffer from them and control them if they are suffering today.

Through this project, an information system was designed and implemented to record, organize and analyze the results of blood pressure measurements. The main objective is to create a platform to record patient data and record the results of tests performed either by a doctor, a nurse or by the patient. The data can be entered and reviewed by means of a mobile application to provide greater accessibility to data.

On the other hand, it is necessary to highlight that this project belongs to a macro project in which it is intended to implement an information system that includes all the possible variables on clinical care and electronic medical records (HCE), which in the long term will allow the complete digitalization and advancement to a new computing era to health entities.

Finally, it is worth mentioning that for this project we intend to use the Fast Healthcare Interoperability Resources Specification (FIHR) [4] communication standard of the Health Level Seven International (HL7) [5] family for the design of this platform, since it is the set of health IT standards more developed and with greater international coverage.

METHODOLOGY

The project was developed using several tools that facilitate its execution and complement in such a way that its implementation and distribution is simple due to the use of an international standard (HL7) which allows the interconnection with different systems because it establishes how they should be structured.

Standard HL7 (Health Level Seven)

It is a non-profit organization that develops standards to minimize incompatibilities between health information systems, allowing the interaction and productive exchange of data between heterogeneous applications, regardless of their technological platform or their development language [6].

HL7 has message specifications, electronic documents and controlled vocabularies for health domains such as: Clinical Documents Architecture (CDA); Medical Records; Laboratory, Medication, Diagnostic Imaging and integration with DICOM (Imaging Integration Domain), Blood, tissues and organs bank; Care Provision [7].

FHIR (Fast Healthcare Interoperability Resources)

It is the latest standard developed by the HL7 organization, focused on the management of several communications protocols in the hospital environment. One of its objectives is to integrate the best features of each of these standards with some modern web standards to allow interoperability between standards.

Because the fundamental principle of FHIR is interoperability whose basic unit (smallest unit that makes sense to exchange) is a resource, the resources are representations of elements that interact in the hospital world (patient, doctor, health problem, observation).
The resources have a series of common characteristics:

- It is a small set of properties that the vast majority of systems currently support.
- It is an extension mechanism that allows implementers to add new properties in a simple way.
- They allow an identification through which they can be registered, located and recovered.

Spring Framework

Spring Framework is a platform that provides us with an infrastructure that acts as a support to develop Java applications. Spring handles the entire infrastructure and so you can focus on your application.

Spring was chosen because it allows the coupling with applications without forcing the user to modify the programming to access the functionalities that it offers to your application. To make use of the features and benefits it offers it is not necessary to implement a spring interface.

Thanks to spring, our Java code can be cleaner, smarter and more reusable. Because the philosophy of spring allows to program oriented to interfaces, so that the application is highly modular and has low coupling.

ARCHITECTURE AND OPERATION

The Initial outline of the Hospital Information System (SIH) is shown in Figure-2.

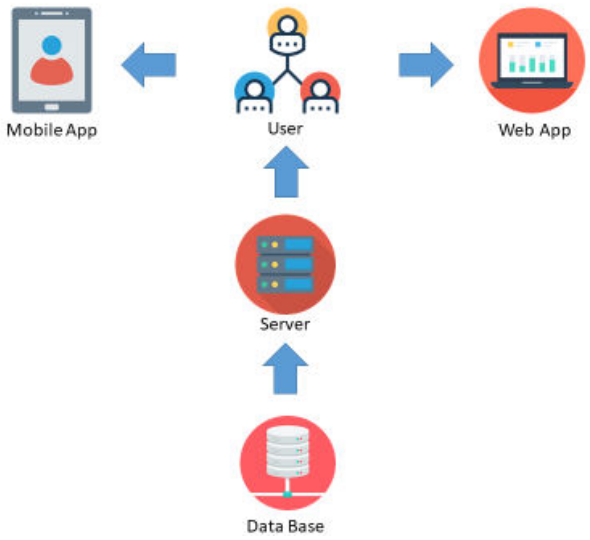

Figure-2. Scheme of the SIH.

In the Figure-2, the SIH model that was developed stage by stage is presented; started with the database (taking into account the established in the FHIR recommendation of the HL7 standard), then the web application (using the Spring Framework) and finally the mobile application.

It is important to highlight that the representation of the data can be done in JSON (JavaScript Object Notation) or in XML which is established in the recommendation, for this project it was decided to make use of JSON due to its dedicated syntax with which the identification and data management is facilitated, simplicity is one of the main characteristics of this language. JSON is an efficient data coding format that allows quick exchanges of small amounts of data between client browsers such as Internet Explorer, Google Chrome and web services, which is why it is considered a large web development library for serialization/deserialization and the transmission of data.

The process that is carried out is very simple; the data (objects) must be serialized, which is a process to convert data into large quantities of bits called Stream, it can then be sent over the network or stored in databases; later, deserialization comes, which the only thing that does is to return an object to its natural state. In this way, the data is transmitted and serialized after it has been stored by means of the user interface; In a complementary case at the time of making queries the data is deserialized and can be visualized [8].

Database server

As a database manager, MYSQL [9] was used due to its popularity, reliability, performance and ease of

use; the implementation was done through MySQL Workbench.

The database contains all the information that is stored for the services of the application; as well as the registration information of both patient and administrator and the variables that have been entered over time.

Figure-3 shows the model used for the database; this model arose from the FHIR recommendation of the HL7 group. It establishes several parameters such as the way in which the database fields should be handled and what information should be handled in each of these, in addition to having a standard form in which they should be transferred; It is worth clarifying that the final model went through several modifications until obtaining the most appropriate one.

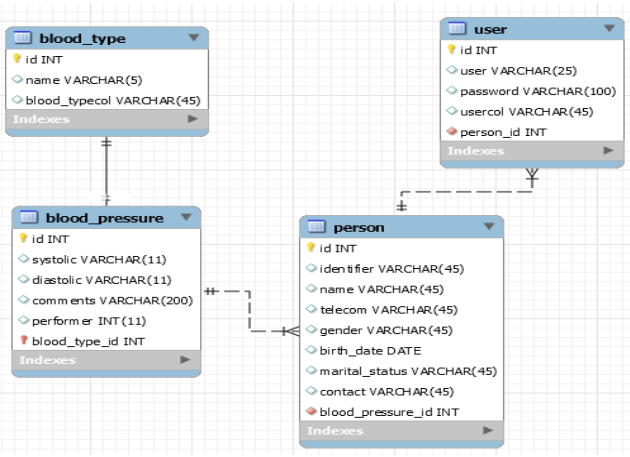

Figure-3. Database model.

Database

The *Person* table contains the information related to the personal data of both patients and administrators; in the name field the names and surnames of the user are stored, in telecom the contact information is found, several numbers of the user can be stored; so on, each field of each table created for the database contains several data in it, it is not limited only to the data with which said field was named. This is possible thanks to the fact that there is also a table called *User* in which passwords are stored and the type of user (administrator or patient) is selected; On the other hand, *Blood_ Pressure* stores everything related to the variables entered by the patient, comments and analysis.

This application allows users to enter the full version of the project in its web version, unlike the mobile version, it is possible to enter as a patient or administrator, the difference lies in the permissions that each of them has.

- **Administrator:** He is the only authorized user to register patients, besides being able to access the information registered by them; He can modify registration forms and view statistics.
- **Patient:** He can see his personal information on the website, in addition to having access to the data that he has previously entered, he cannot modify information (basically he can only see information but not modify it). The interface allows him to enter the blood pressure values and receive a small interpretation of the value entered.

This application fulfills functions such as attending requests received by the Web Server, must interpret them and send a response to the client; in this way it is possible to carry out access to the database.

Among the most general functions performed in the application are:

Authentication: Check that you have permissions to access certain sections, verifying that the user has logged in.

Search: It is necessary to enter data (fill in a form space) in such a way that a search criteria is provided and thus obtain information related to this.

Edition: Similarly to the search, a search criterion is provided (this time it is a "something" to be modified) after having found the necessary value it is possible to click on edit and then save the changes made.

It is worth emphasizing that authentication is possible thanks to the JAAS Java programming interface (Java Authentication and Authorization Service).

Web server

For the development and implementation of this project, the use of a web server is essential, for this reason it was necessary to implement the WildFly web server, in the previous stage an .XML file is mentioned in which the security to be used is established, this is because the WildFly server was previously known as JBoss.

The server is downloaded and configured directly with the Eclipse development environment (through the market place).

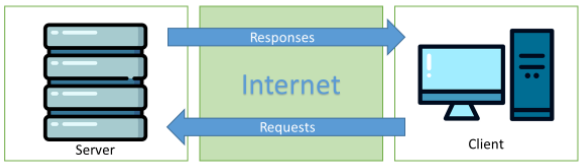

Figure-4. Web server architecture.

ARCHITECTURE OF THE WEB APPLICATION

It is possible to represent the model used in the project by means of the design presented in Figure-5.

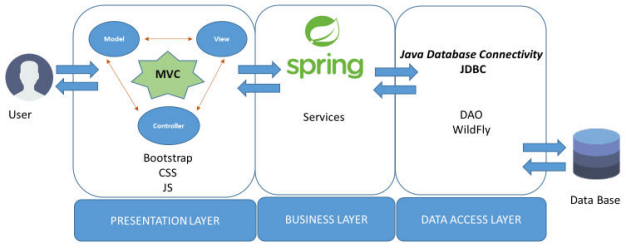

Figure-5. Web application architecture.

Presentation layer. This figure shows the process that is carried out from the moment in which the user makes a request through the interface; which was made based on the model view controller (MVC) and using the Bootstrap and CSS tools because these frameworks allow and facilitated web design in an agile and simple way. On the other hand, the model view controller was used because it was established from the beginning that the project would be developed using spring, which is a framework based on MVC.

Business layer. The programming in Spring was made from the creation of services and implementations.

The services greatly facilitate the creation of a project since a package is created in which the services classes are stored, from which the injection of dependencies is made and thus make use of the great Spring pillars that are modularity and the reuse of code, in addition to the high cohesion.

Data layer. The connectivity to the database was done with JDBC making use of DAO objects which provides a common interface between the application and the data storage devices; On the other hand, the WildFly web server allows the management of the database from a request generated by the user, from there the query is made to the database and a response is given.

WEB APPLICATION

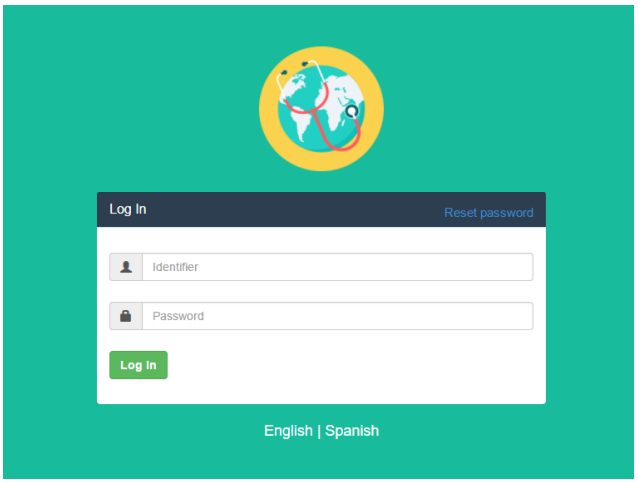

Figure-6. Web application login.

The system has the option to recover the password if it is forgotten (Figure-7); it is necessary to enter the email used at the time of registration, since a new password will be sent (sent from the email bloodpressurerecovery@gmail.com) which will allow access to the platform.

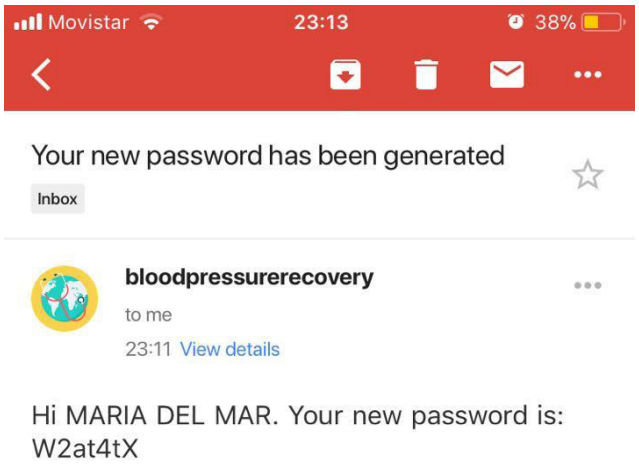

Figure-7. Reset email.

As mentioned above, the application has two types of users; Figure-8 shows an administrator user profile

Figure-8. Administrator login page.

Diagnosis

In this section it is possible to enter the data of the patient's blood pressure, you can also enter a comment related to that value; By saving these data, a small alert appears that makes a small diagnosis regarding blood pressure. The values to obtain can be: Normal, Optimal, Hypertension, Mild hypertension.

Figure-9. Diagnostic example.

Record

In this section it is possible to read the variables previously entered, together with the date and the comments stored.

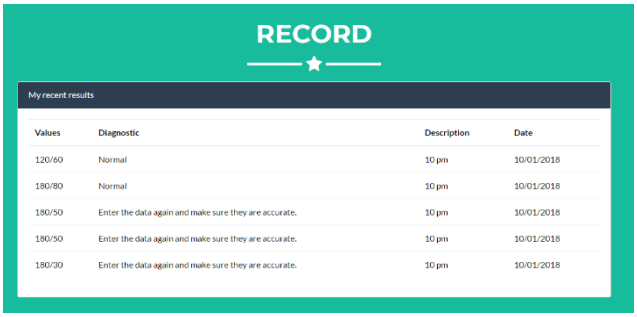

Figure-10. Record.

Statistics

The data stored in the history are plotted; the chart consists of two variables, systolic pressure (blue) and diastolic pressure (red); the data carries their respective dates.

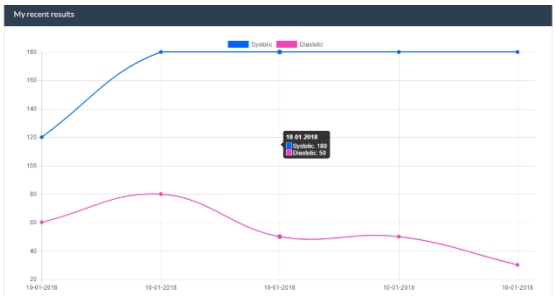

Figure-11. Statistics.

Internationalization

The application has the option to change the language (Spanish/English) according to your need; The language button is at the bottom of the page.

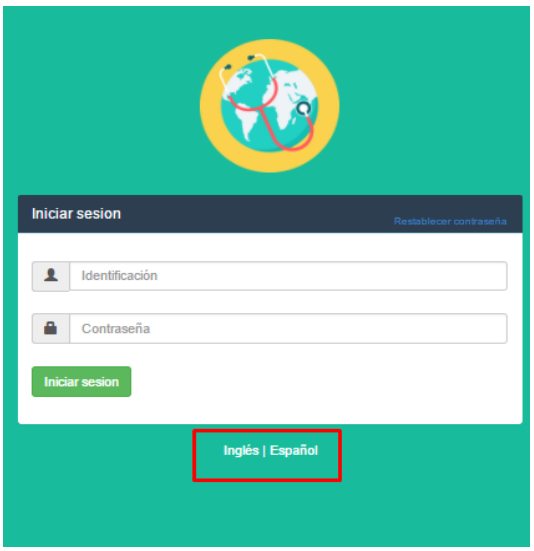

Figure-12. Language selection.

MOBILE APPLICATION

The mobile application developed during the project that allows performing functions for the management of the information registered in the system. In this application, only is allowed access as a patient (unlike the web application)

Figure-13 shows the login screen, Figure-14 shows the Diagnosis screen, Figure-15 shows the Summary screen and Figure-16 shows the Statistics screen.

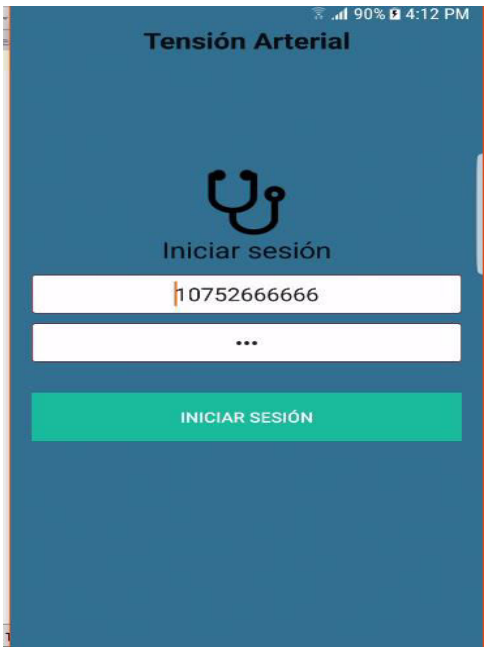

Figure-13. Mobile application Login

Figure-14. Diagnosis.

Figure-15. Summary.

Figure-16. Statistics.

RESULTS

The designed system provides users enter results of blood pressure tests to each patient. In each entered value the systolic pressure value and the diastolic pressure are stored and the respective graphs are made, also date and comments are stored.

Access to history and statistics

The patient or administrator can acquire this information which is illustrated below:

Figure-17. History of entered data.

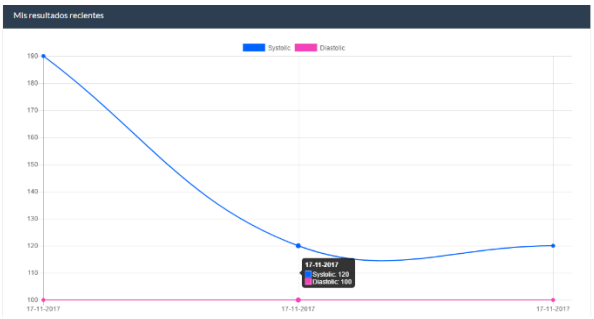

Figure-18. Graphical view of the data.

CONCLUSIONS

It is very important to emphasize that this project arises from the need to give a current and technological management to a very common problem in the local population, since the levels of patients with blood pressure problems grows very fast not only in Huila or in Colombia but worldwide. From this approach it is possible to say that it was possible to design and implement the proposed information system, which provides a help (support) to people who have this type of disease.

After carrying out the respective tests under different environments (patient entry, editions, entry of variables, language changes, etc.), working with the medical advisor, it was possible to receive an approval from him and in terms of functionality it is demonstrated that it fulfills its function and performs adequately and correctly.

With the information system implemented, it is possible to optimize the blood pressure data storage process, saving time and facilitating the work of medical personnel and the quality of life of patients suffering from diseases related to this variable. By having charts, tables and statistics, doctors have the ability to assess the efficiency of a medication or lifestyle (diet) that a patient carries out.

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