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# Application Model (software) for the Comprehensive Management of Cardiovascular Risk in Hypertensive and Diabetic Patients

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**Abstract**

In Colombia, as well as in other countries, cardiovascular diseases (CVDs) are the main cause of death in people over 40 years of age. Hypertension and diabetes mellitus are among the risk factors with the greatest predisposition in this type of pathologies. These diseases are the leading cause of death and yet, there are not enough solutions in the regional context that provide a comprehensive management computer system for cardiovascular risk classification to identify, catalog, treat, and prevent these diseases besides supplying truthful information for actions from the health institutions. For this reason, this research study aimed to design a software for comprehensive management of this risk by using computer tools, starting from the Extreme Programming development methodology. Also, the MySQL database engine integrated with the PHP programming language was used, as well as interfaces of user in the web type HTLML5, CSS3, and JavaScript with the development libraries AJAX, Boostrap, and jQuery. The computerized system for the comprehensive management of cardiovascular risk allows to identify the user's probability of suffering cardiovascular events, generates the opportunity to propose possible interventions, and facilitates access to information accurately and completely, allowing a comprehensive approach to patients undergoing surgery.

**Keywords** - Software Design, software, Cardiovascular Diseases, risk management.

## I. INTRODUCTION

According to Thomas G. Pickering Cardiovascular diseases (CVDs) "are the main cause of death in developing and industrialized countries" [1]. These, along with cancer, diabetes, and chronic lung diseases, are identified as non-communicable diseases (NCDs), showing a rapid increase in recent years. By 2008, 17 million people died from CVDs, equivalent to 48% of deaths from NCDs and 30% of all registered deaths in the world. 7.3 million of those deaths were due to coronary heart disease and 6,2 million to stroke [2,3].

These pathologies are considered the first cause of death in Colombia, since, from 1998 to 2011, 628,630 total deaths were registered due to CVD, belonging to 23.5% of all deaths in Colombia [4].

Regarding the situation at the regional level, specifically in the Department of Sucre, the context area of the study; in 2004, ischemic heart diseases ranked first as a cause of mortality, with a rate of 4.2 per 10,000 inhabitants; in second place cerebrovascular disease, with a rate of 3.4 per 10,000 inhabitants; and arterial hypertension ranked fourth with a rate of 1.4 per 10,000 inhabitants. Based on this, Herrera *et al*, state that "in general morbidity, CVDs ranked second with a rate of 548 per 10,000 inhabitants" [5].

Among CVDs, systemic arterial hypertension and diabetes mellitus along with other factors such as tobacco consumption, sedentary lifestyle, obesity, and others, constitute a series of risk factors predisposing the appearance of cardiac and cerebrovascular complications [6]. People with hypertension have a 2-4 times higher risk of developing coronary artery disease (CAD); therefore, for Galvis "the reduction of 5-6 mmHg in blood pressure reduces the risk of CAD by 20-25%. Nonetheless, when diastolic pressure increases by 7.5 mmHg, the risk of cerebrovascular accident (CVA) increases from 10 to 20 times. The same happens in diabetic people since, according to research, the incidence of ischemic heart disease and other CVDs is higher among those who suffer from diabetes compared to those who do not have this disease" [7].

From the previous perspective, it can be said that the behavior of morbidity and mortality due to CVD in the world, in Colombia, and in the Sucre Department is similar in general terms, since the most recent data establish that CVD is the first preventable cause of death. Nonetheless, for Fagard *et al* "the approach of the institutions that provide health services caring for patients with NCDs is not adequate since they do not have the resolution capacity commensurate with their responsibility, not optimizing their service process. Furthermore, they do not have a regional systematized mechanism that manages to capture, classify, and control the population at risk" [8,9].

When mentioning the phrase "cardiovascular risk", emphasis is placed on the probability of facing a cerebrovascular event or disease in a certain period. For this reason, to calculate the risk of this group of events, two elements must be considered [10]. First, it can be determined what signs and symptoms of cerebrovascular disease can be included, e.g., cardiac and vascular mortality, as well as all the entailing complications, whether fatal or not, which can be from angina pectoris to a heart attack, and others. Second, all the mentioned variables including the calculations are estimated and among these, those

that can be qualitatively interpreted (low, intermediate or high), as well as quantitatively in addition to the probability of suffering complications over a certain period.

To make this possible, there are tables that classify it, "some of the most used are one from the 2013 ESH/ESC Clinical Practice Guide for the management of arterial hypertension, Working Group for the Management of arterial hypertension of the European Society of Hypertension (ESH) and the European Society of Cardiology (ESC) that qualitatively expresses the classification, and another one, the Framingham method, the most used in the world for estimating quantitative cardiovascular risk. These methods were used for the design of the information system" [11].

Consistent with this, it may be stated that it is essential, as element of prevention, to design technological tools that help improve follow-up and control of patients with certain high-risk pathologies, since it will establish the intervention intensity, the need to establish pharmacological treatment and the frequency of follow-up visits. In addition, its prediction has been in recent years, the cornerstone in clinical guidelines for prevention, since it is considered a useful tool for setting priorities in primary care. Every day, these tools generate more interest for improving; therefore, Fedorowski *et al*, refer to "the care of patients and to the choice of more effective therapeutic intervention to follow, which means to go beyond the traditional risk factors" [12].

For this reason, the objective of this research was to design a standardized model for the comprehensive care of cardiovascular risk in hypertensive and diabetic patients to know the probability of suffering a cardiovascular event; in addition to allow to consider possible interventions to minimize them; managing to control causes, to reduce morbidity and mortality, and maintain surveillance and control through public health networks with health stakeholders, leading to improving life expectancy and quality in the adulthood and, above all, an effective strategy that generates healthy years in people lives.

## II. METHODOLOGY

This is an applied research where a software incorporated in a clinical history model was designed to manage the cardiovascular risk of hypertensive and diabetic patients in the Sucre Department to establish a population cardiovascular risk profile aimed at identifying, managing, monitoring and controlling the hypertensive and diabetes population susceptible to intervention. Taking as elements for development of the software, the Framingham method, and in turn, the support of the clinical practice guide from the ESH/ESC 2013 for assessment of quantitative and qualitative cardiovascular risk, respectively, the analysis and design of a web application was proposed. Thus, following the agile Extreme Programming methodology or XP and considering its peculiarities, an algorithm was developed where the variables for the correct classification of cardiovascular risk were included, where the input data of the application are taken, and the score and risk classification of a corresponding patient are returned (figure 1).

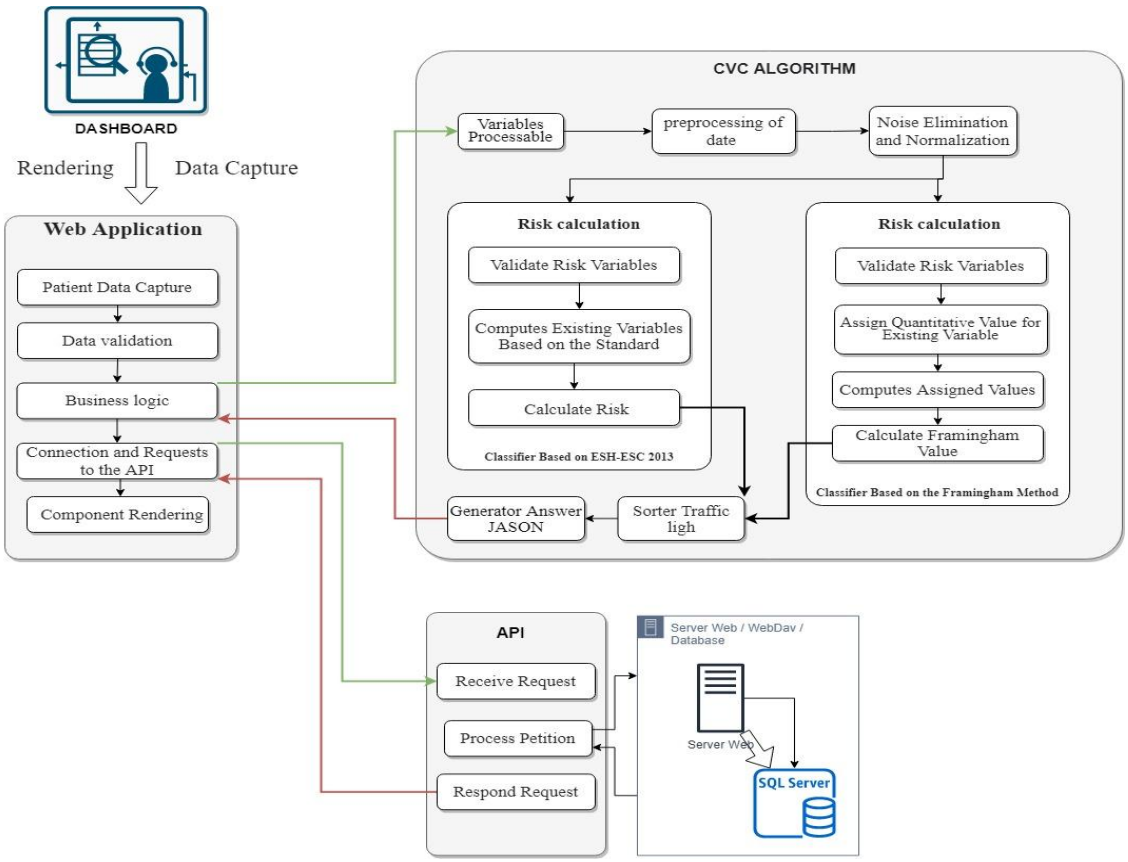


**Fig 1. Systematized algorithm for cardiovascular risk classification**

Once patients are classified according to their calculated risks, they immediately enter the comprehensive care route according to the HTA care guide and the comprehensive health care route (CHCR) in which the cardiocerebrovascular dimension is included. Thus, they are given an annual follow-up with the possible interventions that the interdisciplinary health team may provide [13,14].

Following the planning and designing phases of the methodology, the most important functionalities implemented in the software are described. Also, the roles and responsibilities of the actors intervening in the business, and the processes in which they intervene, are identified (Table 1- 2).

**Table 1.** *System actors*

| ACTORS | JUSTIFICATION |
|---|---|
| Administrator | Manage Users, Manage Customers, Generate Reports, Display Tracking, have full access to all system functions, as well as manage system users and patients to correct errors if necessary. |
| Physician and interdisciplinary team | Manage Clients, Generate Reports, View Follow-up, have access to the system functions related to patients, can generate filtered reports, and view patient follow-up. |

**Source**: Authors' own elaboration

**Table 2.** *Requirements analysis, significant functionalities of the system.*

| Requerimiento N° | Módulo o Aplicación | Descripción del Requerimiento |
|---|---|---|
| RF1 | App | The requirement establishes that every user must be locked in the system to be able to use any function of it. |
| RF2 | App | Only the administrator should have permissions to manage the users of the system. |
| RF3 | App | The system must calculate the Cardiovascular Risk of a patient given certain variables entered by the doctor. |
| RF4 | App | The system must allow the monitoring and schedule assigned to a patient to be viewed after the Cardiovascular Risk calculation. |
| RNF1 | Reports | For the web interface of the report generator, the Apache web server was used. |
| RNF2 | App | The MySQL 5.x Database Engine was used to store the application's persistent data. |
| RNF3 | Reports | The report can be requested at any time through a web interface made in PHP that connects directly to the system database. |

**Source**: Authors' own elaboration

**Methodologies, technologies and tools**

The following software tools were used for developing this project and a brief description of them is made below:

**HTML**: HTML stands for Hypertext Markup Language. It is the most basic building element of a web page and was used to create and visually represent the web page.

**PHP:** Hypertext Preprocessor. They are used for being a term supporting the server, basically elaborated during the implementation of web pages with specifically dynamic and multiplatform characteristics.

**Adobe Dreamweaver CC.** This application was used to build, design and edit the software website as it contains a modern interface and a flexible and fast coding engine uujhh+98n which facilitated the developer's work.

**MySQL.** The implementation of this database generator system is vital since it has a macro characteristic, allowing to deposit a lot of data quickly, reliably, permanently regarding the multiplatform and with a great benefit which is free.

**JavaScript:** To design special effects and in turn interactive activities with the user on the page, it is decided to implement a programming language understood by the multiplatform, that will allow the interaction between the client and the server through mechanisms developed in the HTML page.

## III. RESULTS

What is relevant about this research study is that, in a practical and concise way, cardiovascular risk of patients can be managed to enter into a follow-up route to carry out interventions by the health team and impact on the cardiovascular health of users, i.e., it is not based only on registering and storing information, but rather allows the

comprehensives of a health system based on scientific norms in order to improve the cardiovascular profile of communities.

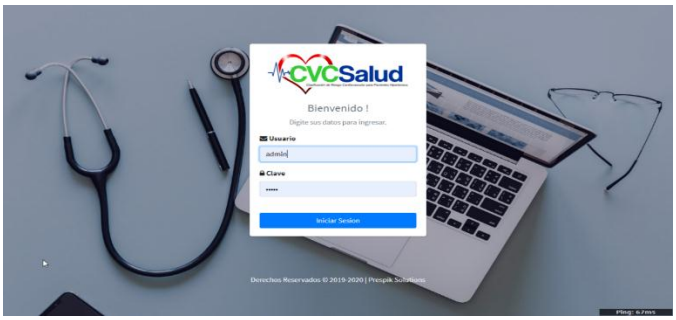


**Fig 2**. *Main interface of the application, user and password requirement to access the application*.

In this research, a dual applicative cardiovascular risk classification system was carried out using variables representing quantitative and qualitative risk factors (Figure 3); immersed in a dynamic clinical history model to project a multilevel approach and serve as a basis for the doctor to make the best clinical decisions and implement new healthy lifestyles for the patient.

ERHARDT (2007) states that "it is necessary to assess all known modifiable risk factors", to provide a detailed profile of cardiovascular disease to guarantee the adequate treatment of each factor in the context of a multifactorial global approach for preventing brain vascular Diseases [15].

The algorithm construction for the classification of cardiovascular risk within the platform using scientifically endorsed methods, facilitated the correct monitoring and approach of each risk, giving the doctor the tools for a timely and directed intervention according to the calculated cardiovascular risk.

Studies carried out using scientific algorithms for decision-making in the health sector have been significant to improve clinical condition of patients. In 2015 Lima *et al* designed software to support decision-making in the selection of diagnoses and nursing interventions for children and adolescents achieving a better clinical approach depending on the patient current condition [16].

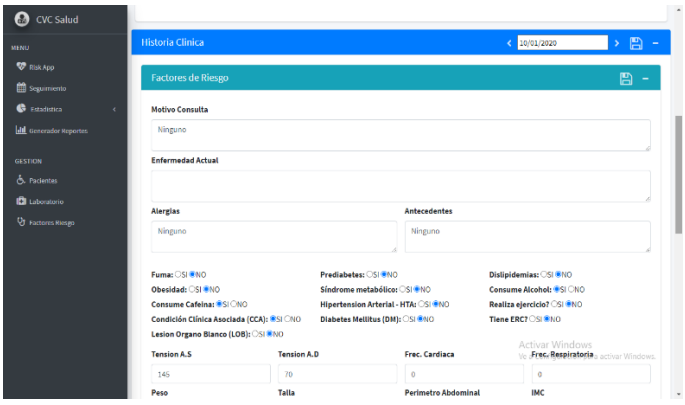


**Fig 3.** *Interface of qualitative variables for construction of the algorithm for cardiovascular risk classification*

In this research, a visual tool was established (Fig 4) that allowed a more fluid and dynamic interaction of the important data of the patient with the user, providing components such as text boxes, drop-down lists, graphics, tables, maintaining superior quality of the data for possible interventions.

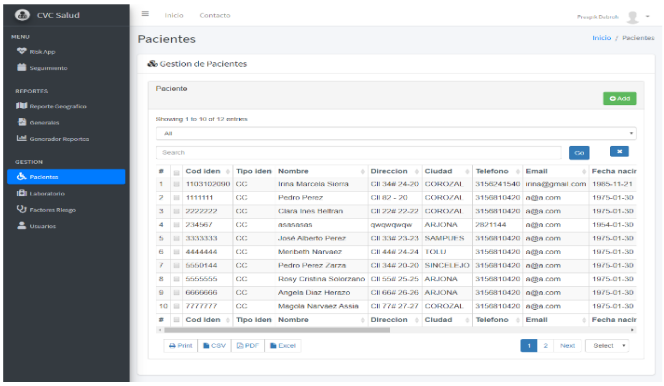


**Fig 4.** *Administrative management portal interface*

According to Rivera Velázquez *et al* 2016, implementation of management systems in technological models "provides access and updating of data in a fast, simple, reliable, safe, and efficient way, the information being available to be consulted at any time", allowing managers to carry out interventions to improve the service [17].

Likewise, the patients admitted and classified by our application are grouped according to the socio-demographic profile that interests the administrator, i.e., all the information will be coded considering the cardiovascular risk profile of the intervened populations to be able to supply them in form of graphs and databases to the territorial entities in health for the creation of policies (Fig 5).

**Fig 5.** *Departmental overview statistical portal interface*

Similar studies were carried out in Cuba in 2019. Martínez *et al* developed a Computer System for Information Management regarding Medical Collaboration that allows managing relevant data of workers in a state, allowing to organize and issue reports and graphic reports making it possible to take the appropriate measures by the company's senior management [18].

Definitively, it is expected that the development of this type of support tools will help health personnel to make decisions in care practice and allow to provide the basis for the articulation of a primary care policy aimed at populations vulnerable to risks, in where the fundamental thing is a preventive approach

including the correction of predisposing factors before the disease reaches its clinical expression. It is no longer justified to wait for signs and symptoms of the disease to appear. In some cases, it is better to consider their appearance more as a medical failure than as the initial indication for treatment. [19, 20].

## IV. CONCLUSIONS

Data systematization as a tool in the improvement of human health is an important possibility to seek the management of cardiovascular diseases and their chronic progress.

Inclusion of cardiovascular risk classification variables in the patient's medical record can facilitate the task of classifying the cardiovascular risk of every user in a timely and accurate manner to establish a personal follow-up control route.

Establishing a systematized algorithm for the classification of cardiovascular risk allows to provide different management alternatives for each risk to reduce complications associated with the cause.

The characterization of the cardiovascular risk profile of a population would allow to integrate the main actors of our health system to propose possible interventions aimed at promoting cardiovascular health with inter-institutional work.

This type of research seeks to intervene in health and provide high-quality information that serves to create public policies aimed at positively impacting morbidity and mortality indicators.

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