

## Implementation and Performance Evaluation of a Mobile Health Application for Auto-controlling of Cardiac Diseases

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### Abstract

The introduction of mobile devices in healthcare has propitiated the creation of a new software industry of healthcare apps. Some of these apps try to help fight against chronic diseases such as cardiac diseases. Since there is a lack of apps for the self-control of these diseases, the app named “Take care your heart” has been implemented. The main objective of this paper is to show this app and its performance evaluation. The process of the creation of “Take care your heart” is divided into different phases. The first is the design of the app, focusing on its functional requirements and its general aspect. The second is its implementation, where the operating system of the app is thought, along with the tools used for its development. The final phase is the validation, where “Take care your heart” is tested in different mobile devices in Android. The interface created offers a clear application easy to use at first time based on image buttons. The response times of “Take care your heart” operations are of the order of milliseconds except for encryption/decryption operations, which can reach around 2 seconds in some devices. “Take care your heart” app was developed and proved to be a good app.

**Keywords:** *Mobile Health; Cardiac Diseases; Heart; Ischemic heart disease*

**Received Date:** March 04, 2018; **Accepted Date:** March 11, 2018; **Published Date:** March 18, 2018

### Introduction

Cardiovascular diseases (CVDs) with 17.3 million individuals dead in 2008 represent 30% of all deaths worldwide. Despite the advances in health care, these numbers are estimated to increase to more than 23 million individuals by 2030 [1-4]. Among the CVDs, heart conditions and heart diseases have an important weight in the burden of deceases. Especially fatal is coronary heart disease (or ischemic heart disease), responsible for 7.25 million deaths in 2008, which, in conjunction with other cardiac conditions, such as hypertensive heart disease and inflammatory heart disease, contributes with a significantly high percentage

**Citation:** Sofiane Hamrioui, Implementation and Performance Evaluation of a Mobile Health Application for Auto-controlling of Cardiac Diseases. Int J Clin Med Info 2018; 1(1) 13-17.

to the global burden of deceases [5-6]. However, not only the deaths caused by a disease are important, but also the disabilities created. Only coronary heart disease caused a total of 62,587 million Disability-Adjusted Life Years (DALYs) in 2008, which give an idea of the huge number of DALYS that heart diseases provoke [7-9].

New health apps are continuously increasing: there are more than 11,000 apps in the category of Health & Fitness and almost 5,000 in Medicine in Android's Google play; and almost 20,000 apps in Health & Fitness section and more than 14,000 in Medicine in Apple's App Store [9]. Focusing only on cardiology, 439 apps for iOS and 271 for Android were found in 2013 in a previous work [5].

Since heart diseases are so significant in the percentage of deaths and disabilities that non-communicable diseases cause, it is obvious that there are many health apps focusing on these diseases. Many of them are designed for patients' use, such as those for monitoring the heart rate in order to detect abnormal rhythms and warn the user [10], others for cardiac rehabilitation [11], some for resuscitation in case of heart infarction [12], and even those for auto-diagnosis, among other types. The authors identified a lack of apps for self-management of heart diseases and conditions [5], deciding to create one with this purpose, being the aim of this paper to present this app called "Take care your heart", showing the outcomes of its design, its development and its validation and acceptance by the users.

## **Methodology**

The process of the creation of "Take care your heart" can be divided into three phases. In the first phase, the authors discussed and obtained the design issues that the app must perform, such as the functional requirements and the general concept of the app. Once the design is concluded, the second phase, the implementation can start.

## **Design**

Before thinking about the design of the app to be developed, it was essential to make a research about the existing apps in its field. In light of these results [1], it was decided to create an app for self-management of heart diseases broadening the scope of these diseases, assessing the most common of them based on the experience of one of the authors, cardiologist for more than 25 years.

The app is divided into three sections: Informative section with medical information about the diseases that will help the patients to understand their disease, its symptoms and its treatment; and a patient guide in order to inform the users about best practices, prohibitions and life style they should adopt in order to improve their condition. Section for registering the users' medications and the hours that they should have them, offering the possibility to establish alarms to warn them. These intakes should be registered in order to create a daily record stored in the calendar. Section to record the user's activities (good and bad for their conditions) and health measurements in order to act in consequence with them.

## **Software Implementation**

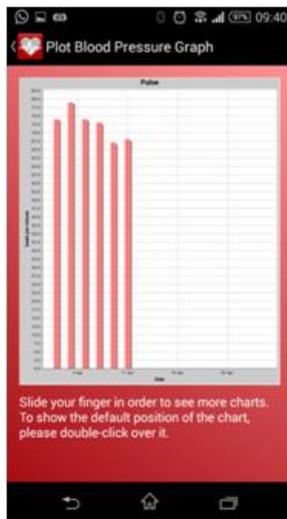
Several operating systems were available for the implementation of the app: Apple iOS, Google Android, Microsoft Windows Phone OS, BlackBerry OS and Symbian. From them, Android was selected because it is the most extended worldwide, is open source and, hence, there are many tools and aid for the development of apps in this platform. The tool used for the development of "Take care your heart" was the Android Software Development Kit (SDK).

Another important issue in the implementation phase was the security and privacy the app must offer, since the data used by the app (personal health data) is very sensitive. About the protection of the introduced data, it was decided to implement the data storage in the device itself rather than in a server or in the cloud. The authors were also especially careful with the implementation of the interface, as it has been proved that the interface design and its easiness of use are essential in order to attract potential users [9]. It has to be simple, intuitive even at first use but also complete, which sometimes can be very difficult to achieve. The validation phase was divided into two phases. The first was the testing phase, consisting in systematic and exhaustive procedures with “Take care your heart”, executing all the operations permitted by the app in several devices with different screen sizes. These devices are the following: Samsung Galaxy Mini GT-S6500 (3.5 inches), Samsung Galaxy S SCL GT-I9003 (4 inches), Sony Xperia Z (5 inches), Google Nexus 7 (7 inches) and Samsung Galaxy Tab 3 (10.1 inches). In this phase the response times of the most time-consuming operations of the app were evaluated in all the mentioned devices in order to check that “Take care your heart” is a sufficiently rapid app independently of the device employed.

## Results

### “Take care your heart” app

“Take care your heart” has got a main page that shows several buttons that connects the different sections of the app. Figure 1a and Figure 1b show screenshots of the calendar of activities and the graphs generated in this case for the registers of pulse, respectively.



(a) Calendar with activities



(b) Graph with registers of pulse

**Figure 1:** “Take care your heart” appearance.

## Performance Evaluation

“Take care your heart” app has been tested in several ways. One of the tests performed was a measure of the response times of the application when executing different actions. Table 1 shows the measure of response times in nanoseconds (ns) when performing different actions. The measures indicated are the mean value of 20 measures for each action.

	<b>Samsung GT-S6500</b>	<b>Samsung Galaxy Tab 3</b>	<b>Sony Xperia Z</b>
<b>Launch</b>	211.826.000,25	56.673.023,81	110.205.078,21
<b>Encryption</b>	2.200.953.999,61	728.293.863,23	788.012.696,52
<b>Decryption</b>	2.319.032.666,42	650.942.188,45	708.050.537,43
<b>Activity DB writing</b>	49.139.777,82	72,071391,45	100.712.367,34
<b>Activity DB reading</b>	25.261.667,09	6.549.713,12	44.937.134,55
<b>Medicines DB reading with 9 registers</b>	15.697.500,45	10.826.702,49	14.175.415,25
<b>Blood test graph drawing with 10 registers</b>	122.416.667,23	59.414.637,13	258.453.369,65

**Table 1:** Mean times (ns) of measurements of some operations with “Take care your heart”.

## Conclusion

In this paper the implementation and testing of an app for the self-control of heart conditions have been explained. The essential steps an app developer should always do are the following. The first step was developing a market research to know the existing apps for cardiology in order to see possible opportunities or deficiencies that can be cover. This is probably the most important step for the creation of a successful app. After this, the following phase is thinking the type of the app, its functions and its design. Once the app is totally designed, the next step is its implementation, thinking thoroughly in which operating systems the app will be available (if not have been thought before in the design phase), since this decision is crucial for the success of the app. Is in this phase where the authors should think about security and privacy mechanisms that the app must implement according to the current laws of the countries it will be released. Finally, it is very important to test and validate the app in order to fix errors and wrong behavior in different devices to be sure that the final version released will be totally operative without errors. It is also recommended to make an evaluation of the app by a sample group of users in order to obtain their feedback and be able to improve it before the release of the app.

Particularizing to the case of “Take care your heart”, the authors were especially careful with the appearance of the app. Focusing on the response times of “Take care your heart”, it is shown in Table 1 that the launch of the app takes about 2 milliseconds in the worst case (the oldest mobile device), much less than the 2 seconds indicated previously. The operation with more time-consumption is the encryption/decryption of the personal data of the user, obtaining 2.2 and 2.3 seconds respectively with the oldest device, being less than 1 second in newer devices. Since these operations are only carried out occasionally, it can be concluded that “Take care your heart” offers good response times in general, which are excellent in the newest devices, taken into account even the encryption/decryption operations.

As future lines there are several opened. It can be possible to improve “Take care your heart” using the results of the evaluation by the users, for example making the interface more intuitive, which was the aspect that obtained the worst evaluation, as mentioned. These improvements can be implemented uploading an update of the app.

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