ORIGINAL ARTICLE
MOBILE HEALTH MONITORING: DEVELOPMENT, IMPLEMENTATION AND EVALUATION OF AN APP FOR CHRONIC DESEASES IN COVID-19 CONTEXT
MONITORAMENTO DE SAÚDE MÓVEL: DESENVOLVIMENTO, IMPLEMENTAÇÃO E AVALIAÇÃO DE UM APLICATIVO PARA DOENÇAS CRÔNICAS NO CONTEXTO DE COVID-19

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Key words: MHealth, Georeferencing, COVID-19

Abstract

One of the most vulnerable sectors of the population to the COVID-19 pandemic are people with chronic diseases. Most of these patients require specialists in referral hospitals. Identifying and geo-referencing these patients is fundamental for Public Health. This work aims to develop, implement, and evaluate an application for mobile devices to detect and perform georeferenced follow-up by governmental health agencies to patients carrying chronic diseases at risk of COVID-19. The use of the application has the potential to benefit chronic patients in terms of the possibility of accessing medication and obtaining primary care from specialists without the need to travel to health centers. The tests carried out show the ability of the georeferencing system to monitor patients and to continue the corresponding patient-physician interaction. **Endocrinol diabtesclin exp 2021 / 2234 - 2240.**

INTRODUCTION

Driven by a technological and health sector, the use of apps in public health has come to be known as "mHealth". mHealth is, as defined by the World Health Organization (WHO), "the practice of medicine and public health supported by mobile devices such as phones, patient mon-itoring devices, digital assistants and other wireless devices" (1).

Health apps open doors to new opportunities for the optimization of public health resources: in the commitment to prevention, in aiding the sustainability of health systems, and even in tele-medicine (2)

In Latin America, the use of mobile applications for patients and healthcare professionals is emerging as the most promising market (3). Applications for chronic patient management could be the fastest growing in the coming years.

Studies show good results regarding the use of mHealth for the management and control of patients with different chronic diseases (4,5), including older adult patients (6). Most of these studies are focused on the monitoring and control of different chronic diseases such as blood pressure or diabetes (6, 10). They combine the benefits of mHealth with the use of sensors and wearable technology. Other studies complement it with georeferenced systems for emergency cases (11). One of the benefits of the use of mobile applications that should be mentioned is their effectiveness in improving diagnosis and medication adherence (12). The challenge of Infor-mation Communications Technology (ICT) is to ensure the interoperability of applications with Electronic Health Record data, as well as to ensure the privacy and security of patients' sensitive health information (13).

Coronaviruses (CoV) are a large family of viruses that can cause a variety of conditions, from the common cold to more serious diseases, such as the SARS-CoV virus that appeared in China in 2002 and the coronavirus causing Middle East respiratory syndrome (MERS-CoV) that appeared in 2012. Both were originally transmitted by bats and palm civets (14). Coronaviruses generally do not cause severe clinical disease in children, but are characterized by causing severe pneumonia in elderly patients and in patients with comorbidities (15). The new SARS-CoV2 virus, which causes COVID-19 disease, is believed to have originated from a live market in Wu-han City, China (16).

COVID-19 viral infection, like other infections, triggers an inflammatory response that is usually confined to the respiratory system. However, there is evidence that in a full-blown case, almost all systems of the body may be involved. In addition, there is the syndrome of cytokine storm, characterized by severe systemic inflammation and a massive release of proinflammatory cytokines (17). It is well established that obesity and diabetes are major risk factors for COVID-19 infections and that the morbidity and mortality in association with these conditions is marked-ly increased. Since both obesity and diabetes are associate-ed with chronic inflammation, it is likely that the inflammatory response to COVID-19 in such patients is affected by the back-ground of chronic inflammation.

In relation to hypertension and cardiovascular disease according to (18), the key points to keep in mind are: hypertension and cardiovascular disease are more frequent in those who have a worse evolution by COVID-19 Patients over 60 years of age, as well as those with cardio-vascular disease, should especially avoid exposure to SARS-CoV-2, not self-medicate and con-sult promptly at the appearance of symptoms.

In the face of a pandemic, there is an urgent need for appropriate technology to, among other things, facilitate the identification of chronic patients. According to statistics from Paraguay, in 2017, 44.3% of the 14,870 deaths corresponded of people under

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70 years of age with chronic non-communicable diseases (19)]. The treatment of chronic patients infected withCOVID-19 is a challenge for physicians and the health care system. It should be said that COVID-19 cases in patients with comorbidities represent a majority in fatal cases (20).

This paper presents the development, implementation and evaluation of a mobile application that allows the georeferencing of chronic patients and their communication with professionals of public health agencies.

The paper is structured as follows: the Methods Section presents the description of the mobile and web software and database development process. The Results section shows the results obtained in the analysis, design, implementation, and evaluation process. The Discussion section presents the limitations of the application. The Conclusions section presents the conclusions of the evaluations reported by the health professionals.

MATERIAL AND METHODS

The georeferencing system for patients with chronic diseases, within the framework of Covid-19, was carried out through the implementation of a web and mobile system that allows communication to a database with exclusive access to Public Health professionals. The mobile application is oriented to patients and the web application to physicians. The development was carried out in four stages: **Analysis, Design, Implementation and Evaluation.**

Analysis

At this stage, with the help of health care professionals, the data survey was carried out to obtain the system requirements.

Two physicians with specialization in public health participated in the study. The first profes-sional carried out a review of existing regional applications for comorbidity monitoring. Based on this, a list was drawn up of the main functionalities that the application could have, adjusting them to the health reality of Paraguay. Subsequently, the second professional proceeded to adapt the functionalities of the application based on the specific requirements of a Chronic Diseases Health Care agency.

The survey of regional practices, the drafting of the requirements and their adaptations for Public Health lasted one week each.

Design

Based on the results of the analysis, the design of the application for mobile devices and the design of the web application and database for information storage were carried out.

Implementation

At this stage, the tools to be used for the implementation of the application were decided. **Fig.1** details the technological stack of the web and mobile application and database.

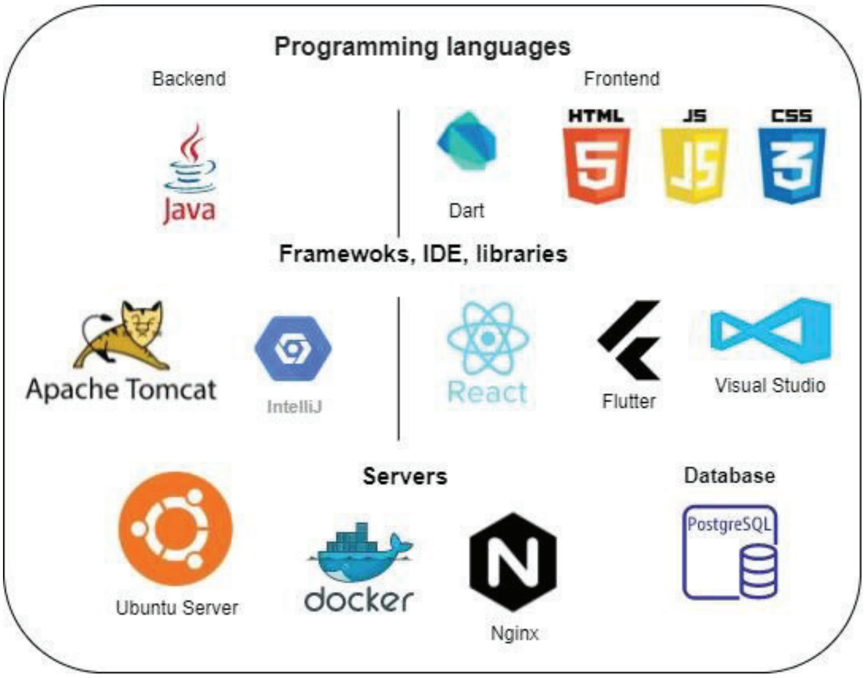
The Kanban software development methodology was used, where user stories were created to be fulfilled in the following phases:

1st phase: Minimum Viable Product (MVP) backend development.

2nd phase: Development of the hybrid mobile application.

3rd phase: Development of tests with the app.

4th phase: Development of the web interface for physicians.



Evaluation

To test the performance between the components, integration tests were performed between the frontend and backend and integration tests between the mobile application and the backend. To evaluate the execution of different user scenarios, tests of use cases and their flows were per-formed. These tests were performed by the Development team through a test server. They were performed on a pilot version of the product that included two physicians and thirty-eight volun-teered persons in Paraguay.

In addition, to measure the usability of the application, a survey to 16 people who previously used the app was carried out. The methodology adopted was the System Usability Scale (SUS) (21).

RESULTS

Analysis

The following requirements were specified for the mobile application and the web applica-tion:

The mobile application is patient-oriented. Through it, patients can register, enter and update their clinical and demographic data, identify care centers near them, and request assistance from a public health agency. In addition, patients can complete the baseline disease form, symptom form and logistic data form.

The data collected by the mobile application are ID card, name, date of birth, gender, ad-dress, geographic location (latitude, longitude), email and phone number. These are necessary for patient identification. Through the demographic location, patients are assigned to the health center closest to their location and, in turn, to the specialist physician.

The web application is oriented to public health care physicians and professionals. Through it, physicians can contact patients and access answers to forms completed by patients. Coordinating physicians can assign patients to physicians in their region. In addition, a list of patients, physicians, coordinating physicians, coordinators, patient assignments and hospital centers can be accessed through the application.

The database server records data related to patients, health--care professionals and healthcare centers.

Medical professionals can create the forms as needed through the web application and can assign them to patients through the web application. Patients through the mobile applica-tion can complete the forms and save the answers, which will be updated in the database.

Design

An initial design was created for the web and mobile application view. The web application has a component-oriented design. The web server has a Model View Controller (MVC) design, where the models are the representation of the database tables.

The database was represented through an entity-relationship diagram. The main data en-tities were: hospital, district, province, person, form, message. The user interface of the mobile application includes the following functionalities: login, personal data, forms, hospital form, base disease form, symptom form, hospitals, asynchronous doctor-patient messaging.

The user of the mobile application can enter the application with his/her e-mail address and password and register his/her data if it is the first time, he/she accesses the application. The per-sonal data option allows the user's data to be registered or updated. The forms option presents the list of forms that the user must fill out as a patient. The hospital, base disease, and symptoms form option allows the patient to answer about logistic data, diseases he/she suffers from, and if he/she has COVID-19 symptoms respectively. The hospital option presents the geographic dis-play of the hospitals closest to the patient's location. The messaging option allows the patient to communicate with the assigned physician.

The web application interface comprises the following functionalities: home, forms, patients, patient assignment, care centers, physicians, coordinators, messages, support. The home button redirects the user to the main page of the application. The forms button presents the list of forms created their descriptions together with the questions contained. The patients button displays the list of patients. The patient assignment button presents the list of patients and the physicians assigned to them. The hospitals button presents the list of health centers and their data such as code, name, district and region. It is also possible to import hospital data from an official health agency website. The doctors and coordinators button lists the data of the doctors and coordina-tors respectively. The messages button shows the messages received from treated patients.

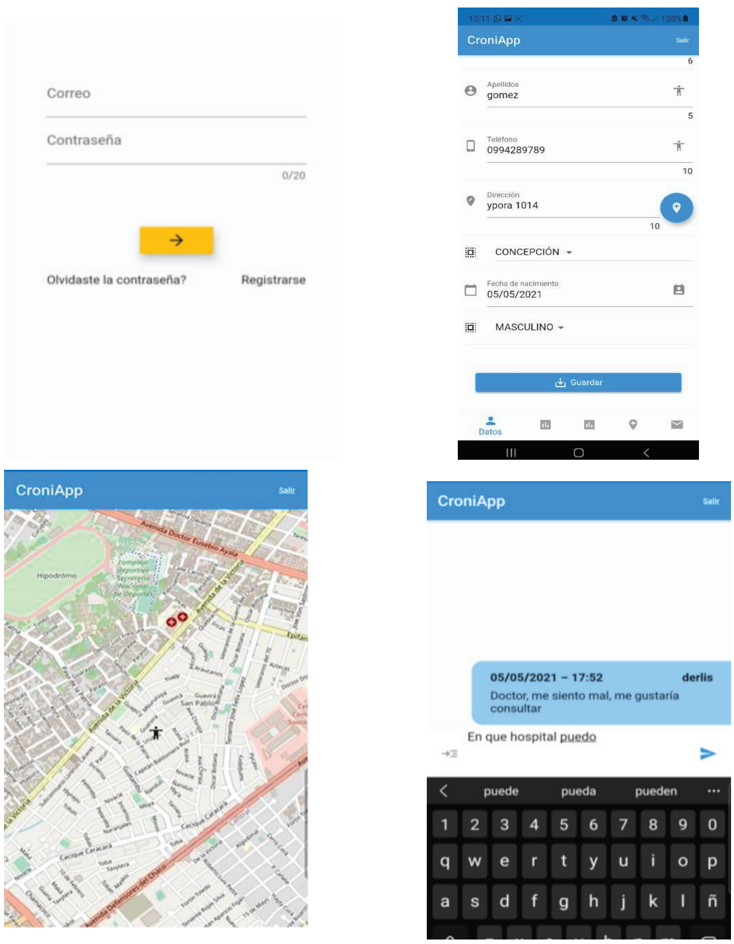
Implementation

The mobile application was developed for the Android operating system, which is the majori-ty system in the population. The security and privacy of the data was guaranteed with strict secu-rity controls for access to the database and the web system. Communication is done via HTTPS and passwords are not shared.

Fig. 2 shows some of the screens of the mobile application such as the login screen, personal data, hospitals, and the doctor-patient messaging.

The login screen allows access to the mobile application and registration in case of first time access.

Fig. 2. Technology stack of web, mobile and database applications.



In the data screen patients update their personal data; the phone number field is required to allow instant messaging with medical professionals.

The hospitals screen displays the location of the healthcare centers closest to the patient's ge-olocation. The geographic location is obtained by requesting permissions from the user and stor-ing latitude and longitude data. To implement geo--referencing, open source data from Open-StreetMap (220] were used, upon user request. To visualize the nearest hospitals, a radius-based algorithm (23) was implemented to obtain the Nearest hospitals in an increasing R radius.

Fig. 3 shows the baseline disease, symptom, and logistic data forms screen. In the baseline disease and symptom forms screens patients select the underlying disease they have and if they are suffering from symptoms. In the logistic data form screen, patients can detail the hospitals they frequent and the medication they withdraw from those hospitals.

Fig. 3. Login screen, personal data, hospitals and asynchronous doctor-patient messaging of the mobile application.

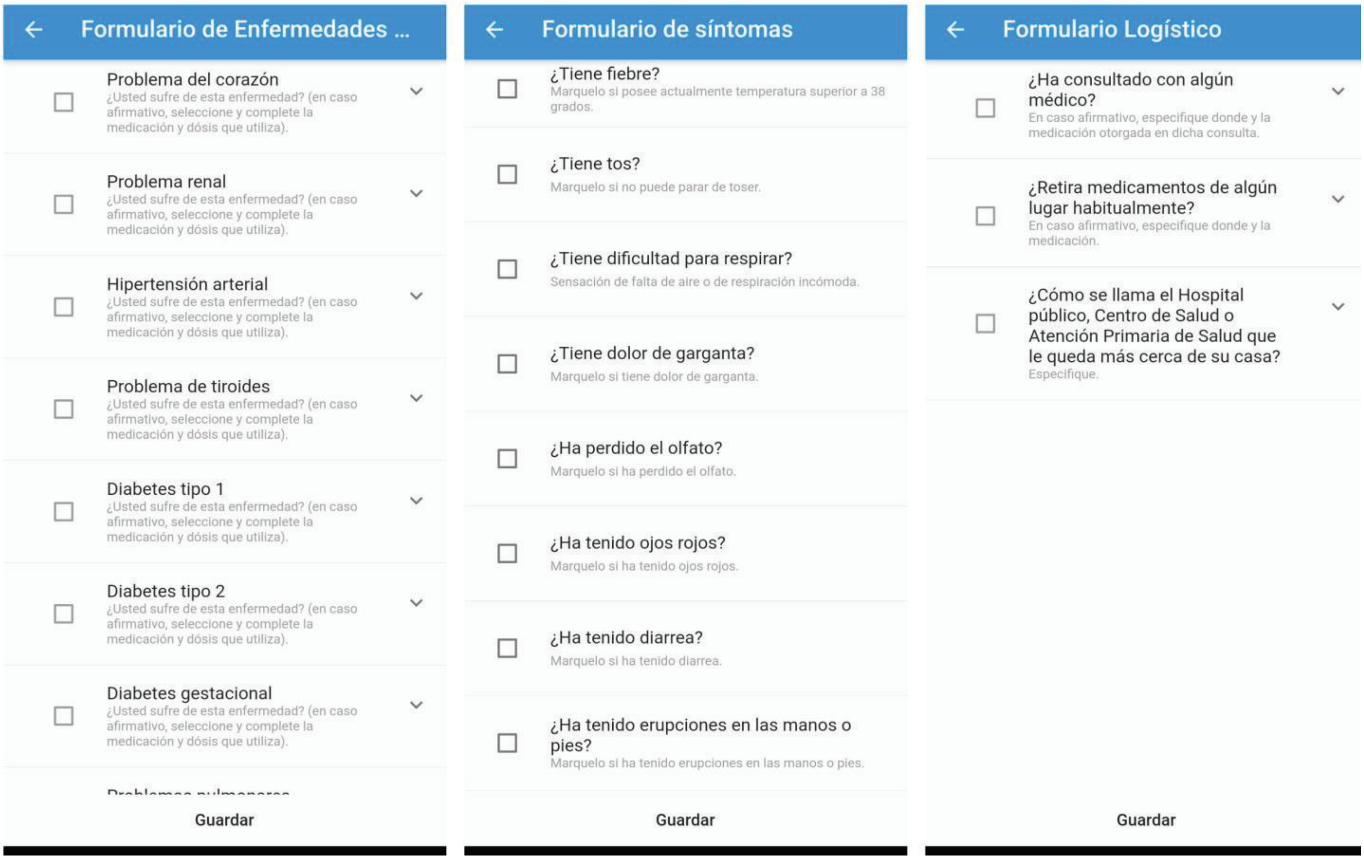


Fig. 4 shows some screens of the web application. The patient assignment screen shows the list of patients and whether they are already assigned to a physician. The care centers screen displays the existing care centers with the option to edit their data or delete them from the list. The physician screen displays the names of the physicians with the option to edit their data, delete them from the list or assign them to specific care centers. The messages screen shows the messages received from patients with the option to enter the corresponding chat and send or re-ply to the messages.

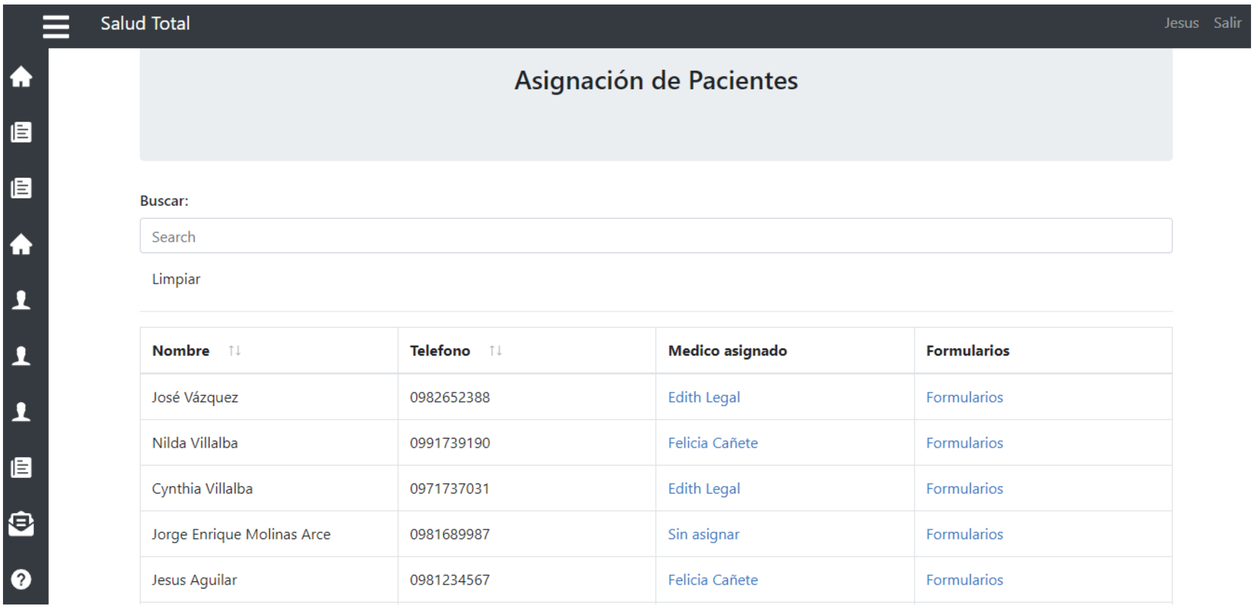
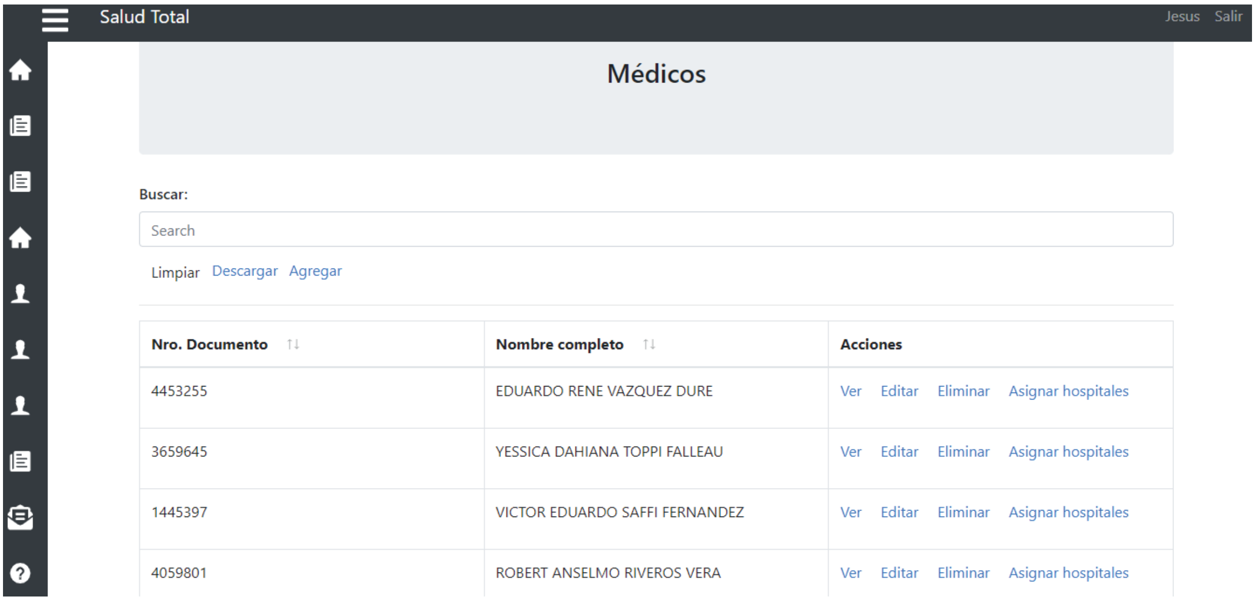
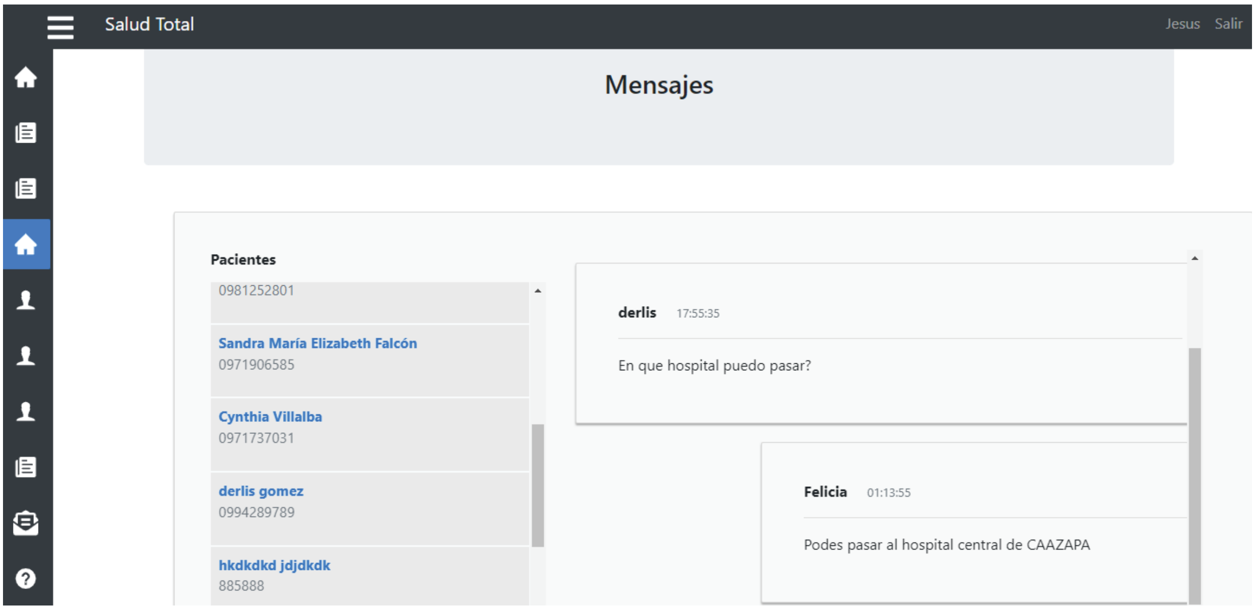


Fig. 4. Web application screenshots: assignment of patients, care centers, physicians, and messages





Evaluation

In the tests conducted, it was verified by the healthcare professionals that the flow between the mobile application and the physician web application is sufficient as a means of com--munication and obtaining clinical data of patients, as well as for monitoring the gravity status of the patients they contact.

In the usability evaluation, according to the SUS scale, the system obtained a score of 68, which denotes a C grade of usability, i.e., it is a usable system on an acceptable level.

DISCUSSION

The application achieves restricted access to patient data by the corresponding professionals. However, in the absence of a policy of correct use of information, there is a risk of publication of sensitive health and patient location data, as well as data leakage by the official health agency.

CONCLUSION

Pilot user acceptance tests indicate that the implementation of a mobile application that feeds a geo-referenced database were able to identify the location of patients and continue with their primary care. In this way, it will be possible to anticipate the care needs of the community, the number of people in the vicinity of a family health unit in order to better allocate the human re-sources necessary for care and visualize the needs of a certain community through the forms and/or messages that patients complete.

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