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The National Health Monitoring System of Panama "SIMONS-SUHPA."

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Abstract:- SIMONS-SUHPA is a technological solution to identifying the least saturated emergency rooms in the different hospitals in Panama City. Healthcare in hospitals requires a better distribution of patients. The overcrowding in the emergency rooms is undoubtedly a day-to-day challenge. Thus this research seeks to minimize overcrowding by efficiently allocating patients to health centers. Via technology, the patient can be provided with information about the best medical care center based on his location, illness, and available resources (medical staff, equipment, among others). Technological innovations today have generated a greater demand for information. Society demands a greater degree of care and better benefits from medical services. In turn, a greater need justifies developing systems with high degrees of efficiency and effectiveness. To improve patients' demands, we propose a web application to obtain information about the hospital centers around him, depending on his location area. The main objective is to reduce the accumulation of emergency patients in these rooms thanks to the application's use, providing real-time information on the number of patients seen.

Keywords: *Context-Aware; Geolocation; Diagnosis; Decisionmaking, Intensive Care Unit.*

I. INTRODUCTION

Today, we can perceive a rapid increase in the number of software (free and paid) dedicated to people's health care and expecting that most of them will play a relevant role in modern medicine in the coming years. Traditionally this type of software has the characteristic of being exploratory (medical imaging, etc.) and preventive. In contrast, others have the intention of maintaining stability and share patients' information with their doctors.

Nowadays, informational applications make it easy for people to locate almost any site using geolocation and other means. Digital messaging has gained preponderance in recent years [1, 2]. In the face of the health crisis following the Covid-19 pandemic, scientists created a system to monitor quarantined patients' vital signs at home. Of these, 70% require medical assistance that integrates a crucial sign collection module such as Spo02, frequency, and temperature and automatically shares it to a platform that processes the data. With the help of geolocation, it could improve the quality and efficiency of emergency services, especially during periods of saturation and future pandemics.

According to WHO [3], COVID-19 has characteristic symptoms such as fever, cough, and shortness of breath. Some asymptomatic patients present no symptoms but are carriers of the virus and are kept in home isolation. According to the above symptoms, we propose the design of a SIMONS Module prototype that can measure, visualize, and record parameters such as Temperature, Oxygen Saturation, and Heart Rate, which, in turn, be integrated into the SIMONS-SUHPA system using the Mobile SIMONS APP application. These parameters are then measured by sensors connected to an Arduino Nano microcontroller that utilizes specific programming to census and process these signals.

As stated by studies conducted by the Ministry of Health of the Republic of Panama [4] in its latest report No. 274, we can see that the number of in-home care patients requires less care than people in hospitals and clinics. In the Panama district, patient data from 10 to 90 years of age have a high incidence in which people of both sexes between 25 and 40 years are those in-home care of which account for 85% of people infected with the Covid19 virus. We consider that these people have access to the internet and will use our information system called SIMONS-SUHPA, allowing medical personnel or people supervising patients in home isolation to have constant access to patients' health status, view alerts, and maintain direct access and instant contact with the patient.

The development of SIMONS-SUHPA consists of the following features: implementing the agile development methodology to develop the applications; a web application developed for both computers and mobile devices designed with PHP programming languages, and JavaScript frameworks, Google Maps API, and Mysql database. The Smartphone App will only apply to the Android platform, directly connecting to the SIMONS module by transferring information via Bluetooth, developed with the APP inventor platform. The measurements captured by the SIMONS module are shared in real-time with the Web platform using the Mobile app. They are gaining instant results on patients' health status using the system and immediate access to the location to require medical assistance.

II. MATERIALS AND METHODS

Tools used for the development of the SIMONS-SUHPA System: Raspberry pi 3B+, USB flash drive 32 Gb, Peripheral elements (display, keyboard, mouse and external memory), APACHE System, PHP, Maria DB SQL, Router Linkys, Programming Environment (APP inventor, Sublime Text), Bluetooth Module HC-05, Arduino Nano, Mini battery 3.7 V 1500 mAh, SPO2 MAX30100 Module, TPA81 Infrared Temperature Sensor, 3D Printer Prusa Plastic PLG for 3D Printing.

A. Development of the SIMONS-SUHPA web platform

The web platform runs on an Apache2 Debian server and Maria DB SQL Server, using the 2.2.2.7 version due to compatibility issues with some of the features. Figure 1 shows the three capable models on which our application is based.

We used the search algorithm of Rani and Roy [5] to explore the hospital center using geodesy with the GPS application and Google Maps API. The algorithm calculates the distance from the reading of the user's latitude and longitude. The system converts this data to coordinates to compare it to the hospital centers registered in the system, storing the coordinates. Hence, it provides the user with the nearest care center, and with the help of the google maps API, the route to the center.

The SIMONS-SUHPA system applies the Haversine Eq.1 large circular distance formula to calculate the shortest distance between a patient and the hospital location as this formula provides greater accuracy. Rani et al. [6] propose a mathematical model for calculating distances and yielding acceptable results within limits established in our system, as shown in Figure 2. For test purposes, the mathematical model shown in equation one was employed. Haversine Long Circular Distance Formula applied in hospitals' distance calculation and SIMONS-SUHPA system users.

$$haversin\left(\frac{d}{R}\right) = haversin(\varphi_1 - \varphi_2) + cos(\varphi_1)\, cos(\varphi_2) haversin(\Delta\lambda) \quad \text{(eq. 1)}$$

From the equation, d is the distance between two points (about a full circle of the sphere), R is the sphere's radius, φ1 is the latitude of point 1, φ2 is the latitude of point 2, and Δλ is the difference in longitudes.

We require programming codes such as HTML, PHP, SQL, and JS to develop our platform. For the database, we have designed three tables within the SIMONS.sql table integrated into our database, as shown in Figure 3. It has a Login, Results, and Data. The database has the following configuration:

- Login, we have the information of the verified users, who are the only ones who have the privileges to view their results on the SIMONS-SUHPA platform. They can also see their daily status and contact the doctor in monitoring duty as the Login maintains two types of sessions

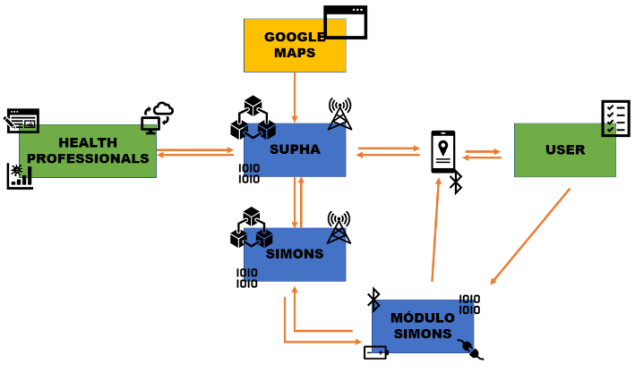

Fig 1. Flow diagram of the SIMONS-SUHPA system displaying the integration of the parts that make up the SIMONS-SUHPA system.

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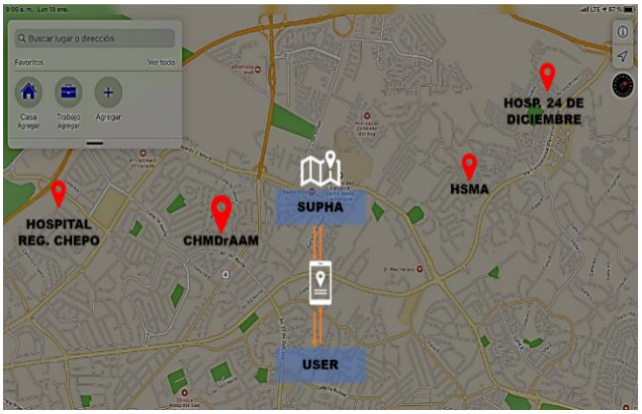

Fig. 2. The search for the closest care center is based on the distance and number of registered patients.

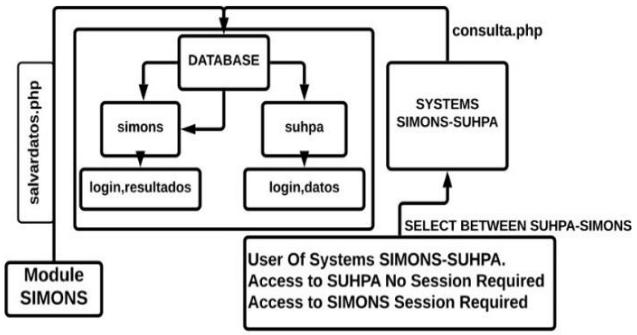

Fig. 3. Communication diagram of SIMONS-SUHPA systems with the database.

(users and doctors). Doctors have access to verify their previously registered patients' data under the Nit parameter, filtering them according to the doctor in charge.

- In the database, the results contain the crucial information shared from the SIMONS module through the Android App channel, where we will have information about the user's number, Nit (identifier of the doctor in charge) parameters: SPO2, frequency, temperature.
- Data is stored in the database on the geographic coordinates of care centers registered on the SIMONS-SUHPA platform. The platform will provide different types of information on hospital care in the future.

Fig. 4. This is the graphical interface disclosing the results executed on the SUHPA system.

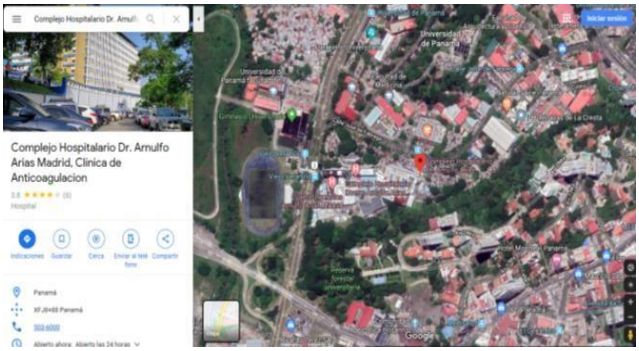

Fig. 5. View of the result provided by the SUHPA system and viewed in google maps.

Once the system is fully operational and the user accesses the SUHPA platform, it will get the information from the nearest care center and an additional recommendation of the minimum number of patients in another care center. The hospital information system provides the latter information see Figure 4. Notice that the hospital's name is in blue, indicating that hyperlinks serve as redirects to the google maps API, offering guided navigation through that application. According to the current traffic, you will also find information about operation schedules and contact numbers, and the most direct route. See figure number 5, google maps API, the world's most used google geolocation application, and google maps offer all this [7,8].

B. Mobile App Development and SIMONS module.

The SIMONS App is developed under the App Inventor development environment based on an intuitive mechanism of function logistics and operations with connectivity through means such as Bluetooth, Wi-fi, and database.

SIMONS consists of 3 windows for user interaction: Start/Welcome window, SIMONS window, and SUHPA window.

- The Start or Welcome window allows us to select the two modes of operation depending on the patient's need: SIMONS-SUHPA.
- The SIMONS window allows the patient to interact with the SIMONS prototype to monitor and visualize Blood Oxygen Saturation, Heart Rate, and Temperature parameters. It also allows the patient to send this captured data to the database for registration and supervision.
- The SUHPA window allows the patient or user to access the SUHPA platform to help them locate the nearest hospital or the one with the least number of patients waiting for treatment.

Block Code for the operation of the SIMONS application windows.

- The Start window consists of blocks with the function to jump to windows with the names described in each block. These functions are preceded by the main block indicating the new window's opening while closing the previous window.

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- SIMONS' Viewing and Monitoring Window. This window allows the reception of numerical data corresponding to Blood Oxygen Saturation, Heart Rate, and temperature parameters. This communication between the SIMONS prototype and the mobile device via the application is done via Bluetooth. The programming blocks consist of functions to recognize nearby Bluetooth devices and select and choose them so that, after selecting and connecting the SIMONS prototype, you will get the patients' measured parameters.

The SEND button sends this measured data to the database, so a doctor or supervisor can remotely evaluate them. It will also send the data in a specific order with the patient's identification and Nit number corresponding to its evaluator [9, 10].

- SUHPA window, When selected, the SUHPA button enters by default to the SUHPA WEB page, under an already default environment.

Figure 6 describes each of the SIMONS App functions, developed under the block logic language in APP Inventor, along with detailed information of each of the parts that make up this APP.

C. SIMONS module

The SIMONS module is a low-cost prototype based on a design accessible to people and simplified use. The SIMONS module comprises an Arduino nano controller responsible for performing the modules' functions accompanied by temperature sensors, Spo2, and heart rate.

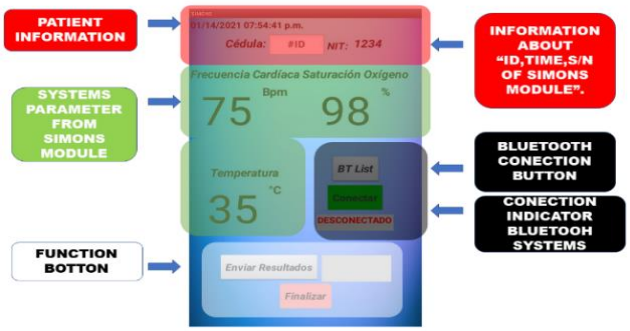

Fig. 6. APP SIMONS communication mobile interface with SIMONS Module.

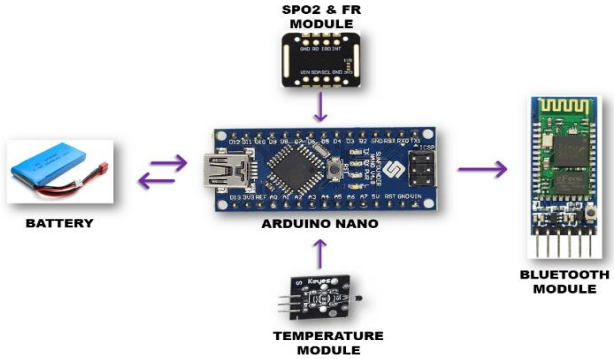

Fig. 7. SIMONS module connection diagram.

The module's operation is limited to the module's power utilizing a power button that immediately starts the data collection process by the temperature sensor and the Spo2 module; with the SIMONS App, we can get the command to capture results and send them to the SIMONS web system.

The prototype's development was based on small and durable portable equipment that complies with the characteristics based on its development. Once the prototype was developed in the drawing and rendering software, we printed and assembled the internal circuit.

The SIMONS module uses Arduino nano modules, MAX30101 Spo2, and a temperature censored module [14-16]. For communication with the SIMONS App, it is based on data transmission using the Bluetooth communication protocol. This modular prototype does not require high energy use; that is why we used a 3.7 volts lithium battery at 1.7 Amperes see figure 7 showing the essential components of the SIMONS Module.

III. RESULTS

Currently, the SIMONS Module Prototype sends real-time parameters registered by the end-user. These parameters are entered into the system, where we have information about the day and time of admission and the patient's physiological parameters. It is worth mentioning that the system can identify when the parameters are out of the established ranges by the supervising doctor. The color code is as follows: green (standard parameter), yellow color (normal average), and red (out of range). Red implies that the patient requires attention. Additionally, we have the WhatsApp contact tab to provide direct contact with the supervising doctor if there is a need for medical assistance. The WhatsApp button redirects the user to the Mobile WhatsApp app and sending an alert containing the following message "Help; I require medical assistance + Person's location," which is the main parameter for any emergency care service to access the person's location.

Regarding the SUHPA platform, the Republic of Panama's capital district's main hospitals have been admitted to the system: CSS Hospital Complex, HSMA Minsa, Bethania Css Polyclinic, Hospital Clinic The Panama clinic Privado. Tests have been carried out according to a strategic location within the district with acceptable results thanks to Haversine's long circular distance formula, as shown in Figure 9. The final result is displayed in the google maps API with the trajectory from my current location registered by the SUHPA application and resulting in the nearest care center from my current location in Parque Lefevre, the capital district.

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IV. LIMITATIONS

The SIMONS-SUHPA system is limited in the first instance to the platform's use in the Republic of Panama's capital district, as all hospitals require data collection in the Panamanian Republic. Nevertheless, for validation of functionality, it is feasible to apply only in that region since it comprises 45% of the republic's population and at the level of affectation by COVID 19 60% of the active cases within the republic are within the capital region according to the data provided by the Ministry of Health.

Concerning the SIMONS Module, we need permission, from the Ministry of Health, for validation and use with in-home care patients and proceed to manufacture the specific quantities for their use by Covid19 positive patients in home isolation.

Today, our platform is hosted on a primary server, which is enough for the development and functionality testing of up to 10 people accessing at the same time. When more people start using our systems, we will move to more powerful servers to meet our system's query demand and avoid a breakdown.

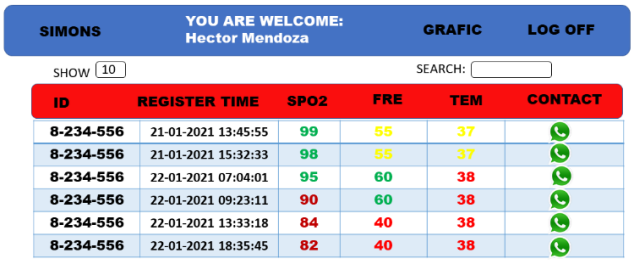

Fig. 8. This is a graphical interface disclosing the results according to each patient on the SIMONS module's vital signs.

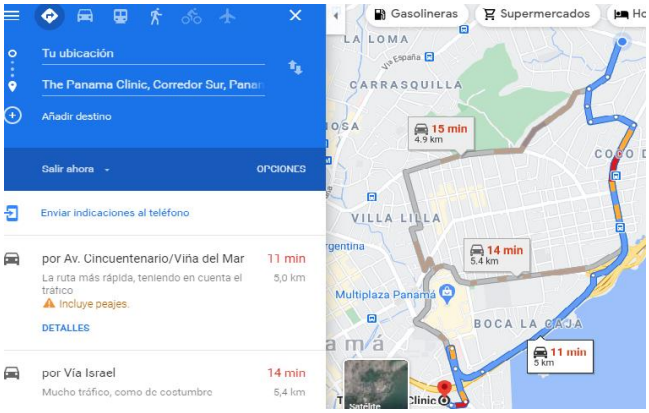

Fig. 9. Results provided from the SUHPA platform.

V. CONCLUSIONS

SIMONS responds to a prevailing need to monitor the health status of patients who are in home isolation. The development of this type of application contributes to the work carried out by health authorities and professionals on the battle line against this disease.

The SIMONS Module meets the requirements of low cost, ease of use, data collection, and traceability of the patients' vital signs. During the pandemic, we managed to integrate the SIMONS-SUHPA platforms to provide a traceability tool of physiological parameters (SpO2, HR, and Temperature) for patients infected with COVID-19 who are in home isolation. Furthermore, it searched for a hospital-based on its proximity, number of patients waiting for care and considered non-infected COVID-19 patients who require urgent medical attention. SIMONS offers the user and the health entity direct contact and continuous monitoring of the patient.

The platforms used to design the website and the android application are free and with a standard programming language. It was possible to integrate valuable and functional tools to acquire, store, and visualize the parameters or data.

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