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Original Article

Multiplatform Mobile: Post-COVID-19 Patient Management in Lima, Peru

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Abstract *- This research aims to develop a multiplatform mobile application for managing post-Covid-19 patients in a Lima Hospital. The research used the Dart programming language and the Flutter framework to construct the multiplatform mobile application; for the REST services, the PHP programming language and the Laravel framework were used. Finally, all the information is stored in the system. of relational database management, MySql. For the project's development, it was decided to use the Scrum methodology, which was divided into four Srtint. All the needs extracted from the user stories collected by post-Covid-19 patients and medical personnel were reflected. , obtaining as a final product the mobile application and the master manager; finally, three technology specialists and two health specialists used expert judgment to measure the results. As a result, high satisfaction of 88.4% in the criteria: usability, scalability, technology, feasibility, and innovation; in this way, the product is validated for use in a Hospital in Lima.*

Keywords *- Covid-19, Flutter, Mobile application, Pandemic, Patient management.*

1. Introduction

Health management is currently a key element in the well-being of all; the health situation that has emerged worldwide since the start of the pandemic, at the end of 2019, with the appearance of the SARS-COV-2 virus, has shown that there is a deficiency in this sector, no country was prepared to face such a scale in health demand.

As pointed out by [1], in India, which is part of the countries with the most reported positive cases, the poor management of patients, added to the limitations of medical resources and specialized equipment available, has led to a rate of mortality of up to 97% for patients admitted to intensive care. Medical care capacity in hospitals has been oriented towards these cases, leaving aside patients with minimal or moderate symptoms, whose treatment depends entirely on the controlled care carried out by medical personnel; these can be carried out through remote assistance. From the position of [2], at the beginning of the pandemic, the US did not carry out strategic management to treat patients with COVID-19, downplaying the virus and misinforming the population. Consequently, this led them to an exponential growth of positive cases. Although the country has advanced medical technology, the mortality rate was 3.77% of the number of positive cases, ranking fourth below Brazil with 3.8%, Spain with 9.25%, and Mexico with 11.56%. As [3] expresses, the fragility of the Mexican national health system and the uncertainty generated by the state, municipal, and health authorities have caused an increase in the mortality rate. These figures have not been totally clear. As evidence of the precariousness with which the treatment of COVID-19 patients has been managed, the insufficient tests applied to citizens with the prevalence of symptoms, delay in the management of health procedures for containment, absence of protocols for the management of patients and relatives, lack of equipment and job insecurity of medical personnel. What has been described above is part of Mexico's current situation, which is within the ranking of countries with the worst pandemic management. According to [4], the coronavirus has caused a great impact on hospitals and world health systems; however, there were protocols to manage a large influx of patients, and there was not the proper preparation to face a pandemic, with the high demand that means this and under the same protocols. The available medical resources were distributed as equitably as possible to optimize care, and the medical staff made the difficult decision of choosing who had the best chance of surviving to allocate intensive care resources. Thus, it has led to work stress and psychological problems that impact patient care.

In Peru, the state of emergency began in March 2020, but the deficiency of the health system gave way to poor strategies during the pandemic. As indicated [31], the Minsa began in March 2020 to publish the first Ministerial Resolutions that serve as a basis for treating and managing

patients with COVID-19; these had to be complied with by all institutions that provide health services. However, these guidelines were not entirely clear in the decision-making process, leaving the judgment on the use of these, as in the case of medications, to the medical staff, considering that they did not have the studies to support their effectiveness. Likewise, [6] indicates that Peru was one of the countries with the most positive cases and deaths in Latin America; the failure to contain the virus and the poor management of patients was due to the precariousness of the health system; there were not enough laboratories To carry out tests, there were no ICU beds available, nor medical equipment such as respirators, and the demand for care was greater than what could be met, which caused the collapse of hospitals and medical centers. On the other hand, the strategies that do not apply in a Peruvian scenario, but that compliance was demanded, generating rebellion in large part of the population unaware of the impact and criticality of the virus.

On the other hand, [7] states that Minsa has developed various strategies to support the pandemic. However, the response capacity that these health centers have is not visible since the number of positive cases continues to increase. As a solution, the Minsa has also issued ministerial resolution 182-2020 / MINSA, where guidelines are proposed that will serve as a basis for the necessary activities in the management of COVID-19 patients; it can detail two key points that are: guidelines for home monitoring in mild cases and care after hospitalization and the guidelines for health care through ICTs, as well as the delivery of instruments to the patient's home for control and monitoring. The objective of these guidelines is to improve patient management by preventing virus transmission through health facilities and proactively identifying alarm symptoms for their respective referral to a medical center. In the words of [8], he points out the importance of including ethical practices within a virtual medical care scenario, considering that the virtual management of a patient must include quality, safety, transparency, and continuity. Peru has seen a recent growth of initiatives that offer virtual platforms for a remote medical service, several of which are not designed under ISO/TS 13131 (guidelines for telehealth, telemedicine, or m-health projects), which impacts quality and safety, not having support or confidence in its use. It should be noted that in May 2020, and through Legislative Decree No. 1490, it was included in the Peruvian regulations to strengthen telehealth services, as well as regulate the use of electronic prescriptions.

This investigation is based on the information obtained from a Hospital in Lima and administered by the Ministry of Health of Peru. Considering the problems described at the global and national levels, COVID-19 has shown that they are not prepared to meet the great health demand; even world powers and countries with stable economies have collapsed at the level of health services and virus containment, leading them to make poor decisions and strategies that directly affected the population. To avoid unnecessary travel to the medical center and, consequently, the crowding of the public and the demand for care, as well as reduce limitations due to medical capacity and improve the patient experience, ask ourselves: How does the development of a mobile application in the management of post-COVID-19 patients?, which will be progressively demonstrated as the research project progresses; being opportune its application in a massive way and thus be able to contribute to society with a useful, dynamic and accessible application for those responsible for health care by COVID-19. The gap in the study is that there is a lack of a greater strategy for carrying out decision-making in the health sector. In the technical part, with the use of multiplatform, it should be enhanced by optimally performing all its processes. In this way, the existing gap is minimized.

The research aims to develop a Multiplatform Mobile Application applying the Scrum methodology to manage post-COVID-19 patients in a Lima Hospital.

2. Literature Review

According to the investigation of [9], developed in Loreto, the problem lies in the number of positive cases of COVID-19 that caused the saturation of health centers, reaching a point where it not only affected the general population if not also the medical staff. Among the main causes of this collapse is the deplorable infrastructure of health centers, and the availability of medical personnel, considering an average of 19.1 doctors per 10,000 inhabitants. Loreto is in a geographical location that makes it difficult to access health centers quickly, so it was necessary to evaluate new strategies that allow detecting and monitoring mild and asymptomatic cases of COVID-19, thus avoiding unnecessary displacement, which would collapse. The health service. For this reason, an application was developed that allows the surveillance and monitoring of these cases. This project was financed by CONCYTEC, which aims to mitigate the impact of the pandemic in the Amazon area of Loreto.

For the development of the application, the software model "MODELO-V" and Commcare, the Model V, were used, which allows knowing the risks in each stage of implementation since each of these is attached to tests. On the other hand, Commcare has two modules, Commcare HQ and Commcare Mobile; health workers use the second to register and monitor cases. As an instrument, questionnaires were used for the community, where based on questions, the medical staff could detect symptoms and possible positive cases. The study of the project was divided into 4 stages; the first was about coordination with the health center, the second was about the development of the application, the third was the implementation stage that included home visits for the questionnaires, for last, the feasibility study of the

mobile application. The sample comprises 1,290 residents belonging to 629 dwellings in the same city. The study concludes that it was technically and operationally feasible, allowing the community's intervention to detect positive cases on time through a mobile application and a follow-up of residents with suspected cases, to whom a survey was carried out. Daily follow-up. As a result of the sample, 72 inhabitants with suspicious symptoms were obtained, of which 48 have a risk factor as an older person, prevalence of diseases, and pregnancies, among others. The attention time per person was 11 minutes, and the face-to-face intervention was totally under biosafety guidelines.

It is directly related to research because they meet the objective of using a technological tool to monitor cases in a pandemic context. It is beneficial for reducing unnecessary visits to a medical center and minimizing biological risk.

Another alternative is presented [10] in his project, where he carried out as a solution the development of a web and mobile application to be able to carry out remote medical care for older people who were diagnosed with type 2 diabetes. The investigation aims to maintain continuous control and reduce the aggravation of your disease due to non-compliance with glucose treatment and control. The proposal was aimed at both parties; on the patient's side, modules and information about their disease, medications, treatment, and glucose control are shown; on the other hand, the doctor will be given access to manage patient care and control video calls. The project was executed in a nursing home for the elderly and with a specialist in Endocrinology. An endocrinologist specialist and three patients over 60 years of age with type 2 diabetes were included in the tests. The training was provided on the use of the application and the method to perform the tests; for this, all patients had a personal glucometer and a cellular device with internet access. Once the clinical history entry process is finished, the patient will be evaluated for weeks to record their activity; later, they will be asked to complete a satisfaction survey on the application that will allow for measuring its efficiency. The questionnaire scale is based on Likert. The study concludes that initially, the patients did not record their activity frequently, but during the second week, they began an adaptation period, becoming part of their routine. Likewise, the average response time by the doctor was measured, reaching an average of 4.13 minutes. The benefits included that the patient has autonomy over the follow-up of their disease through a device within their reach. In turn, the doctor is qualified to provide treatment to the patient and the respective follow-up; an additional module with what counts the medical staff is access to the indicators and reports of all treated patients. It is directly related to research because the study confirms a 14% reduction in the complications of the disease due to efficient monitoring in medical controls. Therefore it can be replicated as a solution to different diseases or part of remote medical management, which also allows monitoring based on information technologies and the use of applications, benefiting the patient who may have limited mobility. The modules included are also highlighted, such as medical appointments, knowledge base, treatment, and reports.

In the project [11], anemia's negative effect on the population is addressed, specifically on children and pregnant women. No record and digital control of patients would allow the evaluation of new strategies and decisions. For this reason, the design of a web platform for managing patients with anemia using the SCRUM methodology has been proposed. This investigation was carried out at the New Maternal and Child Health Center of Carabayllo; the establishment is the Growth and Development area (CRED), where the registry is manually administered, which leads to greater failures and poor follow-up of the treatment. The application seeks benefits such as a fast digital record, medication control, scheduled appointments, constantly notifying patients as reminders and a report module that shows the evolution of the treatment. The methodology used is SCRUM, chosen for flexibility when working with Sprints, time reduction, and adaptability to changes according to needs. The Sprints were divided into four stages: medical personnel registration, patient registration, control and treatment, and consultations and reports. In the development stage, tools such as Trello were used, which allows the creation and monitoring of sprints, Adobe XD to design the models of the interfaces used by the application, programming languages in PHP and JavaScript, MySQL database, administration free, and the MVC architecture. It is concluded that there is a saving of time in the digital registration of patients, complying with the follow-up of the doses. The CRED area's medical personnel saved time coordinating with their patients and managing to generate regular appointments so that the mother or the infant could continue their treatment. The relationship with research is based on the methodology used; SCRUM will allow us to control each stage of the project, proactively detecting errors and allowing us to carry out continuous improvement and guaranteed delivery times.

In the investigation of [12], the need for a solution that supports the reduction of workload for health personnel is noted; this is because the current demand for care has exceeded the capacity of the personnel, which leads to work stress and, as a consequence, poor patient care. Remote monitoring through a web or mobile platform would reduce mobilization to the hospital or medical center, obtaining benefits for both the patient and the medical staff and ensuring that the time saved is directed toward more critical care. Although there are no conclusive studies on the remote management of respiratory diseases, there are successful cases of treating diseases such as diabetes, heart failure, or anemia, including a study with a 68% reduction in admissions to the ward of emergencies. The impact of a

telemedicine solution shows that technology improves patient management, gives greater visibility to follow-up, and allows fluid communication between health professionals, allowing quality general care. The study was conducted on patients with low and moderate symptoms who were close to discharge and should be monitored from their homes. Patients have two options, the first, monitoring by phone calls only, and the second, monitoring by phone calls and mobile applications. In the first case, the health personnel called to consult with the patient about improving symptoms and compliance with physical activities. For the patients who chose the second type of monitoring, the Huma Therapeutics application was enabled; through this application, the patients underwent daily heart rate, oxygen saturation, body temperature, symptoms they presented, and respiratory distress. It was measured using a Likert scale, with 1 being the minimum and 5 being the maximum. Based on the recorded data, the doctor decided whether a phone call was necessary. The tests were carried out for a month, and each patient was monitored for 14 days. The results show that it will be possible to control the medical workload with the measurement of the duration of the calls per patient; 56 patients chose type two monitoring, which consists of the application plus the telephone call; it was found that the average time of calls was 8.5 minutes and the total number of hours consumed is 31.73 hours. Considering that all the patients had called, there would be a total of 79.33 hours, equivalent to 47.6 fewer hours saved.

Regarding physician availability, 7 physicians were assigned to care for this group of patients; the average data review per patient was 10.9 minutes. Remote monitoring would optimize resources and minimize unnecessary contact; an application is a useful tool to prevent patients from crowding into a medical establishment, so critical cases are prioritized, and biological risk is minimized. This research is of great importance since it shows us that an application would allow monitoring large numbers of patients, considerably reducing the time used by medical personnel, helping to minimize the current high demand, and maintaining the necessary distance. The research is related to the main objective of developing a mobile application that allows the management of post-Covid-19 patients.

The author [13] presents a measure in the face of the growing burden on hospital medical care. This tool allows digital monitoring for Covid-19 patients to optimize resources, limit face-to-face interactions and prioritize care toward patients with more serious conditions. The study was carried out in Malaysia, and here the statistics confirm that, for each positive case, there are 16 suspected cases. For the follow-up of cases from the patient's home, there was a procedure that included the medical staff making calls to the patient for 14 days. Daily, a questionnaire was made about the symptoms in each call and manually required more time. With this, the need in Malaysia for the use of technology for digital monitoring is evident, having more benefits to the group of patients that need to be applied and thus reducing the current burden on the health system. For the development of the CoSMoS application, the agile methodology was used, which was preferred over those already existing in the market due to the benefits of this methodology, such as scalability and adaptability, considering that the Covid-19 is in a changing context, the software requirements should also be. Hence, the development methodology is needed to support these rapid changes. The research team was made up of doctors and specialists in IT and health; they were divided into work teams, which helped in the rapid implementation, and the application was completed in 19 days. CoSMoS uses the Digital Ocean cloud, is implemented in JavaScript and MongoDB, and uses FreshDesk as a help desk. Likewise, other tools, such as Slack, Trello, GitHub, and WhatsApp, were used during the process. The project was divided into three phases, the first, where the system requirements were identified; the second, the application's development that included two environments, test and production; and finally, the inclusion in the medical center; in this the last phase, medical personnel were trained on the use of the system. The application allowed that, based on the patient's registered information, the contact option for a teleconsultation would be displayed as a result. If there were no changes, the patient could continue with their activities. An application was obtained that demonstrates that remote monitoring of a patient with mild or moderate symptoms is feasible.

On the other hand, when having access to confidential information, security is a priority. For this reason, authentication and authorization mechanisms were implemented in access, and security policies were well-defined. The research is directly related to the objective, considering, as a solution to the problem, the implementation of an application that allows post-Covid-19 patient management, reducing the current saturation of health centers.

According to [14], due to the growing demand for hospitalized patients, which caused resources to be limited, a remote monitoring program was implemented for patients who were discharged, the follow-up would be carried out from home, and a pulse oximeter and a thermometer would be used. The data would be entered through the application, and the medical staff for decision-making will monitor these data. The objective of the application is to maintain the continuity of post-discharge care, minimize contact with medical personnel and the spread of the virus, and reduce the demand for face-to-face care in the hospital. The population that participated in this research were patients belonging to the Massachusetts General Hospital and Brigham and Women's Hospital in the pilot and later extended to three more hospitals, Newton-Wellesley Hospital, Brigham and Women's Faulkner Hospital, and North Shore Medical Center. Enrolled patients were provided with an oximeter

and a thermometer free of charge, as well as assistance for registration in the mobile and web access application, the application notified daily of the entry of symptom data and questionnaire in the application if the patient was within the saturation range greater than or equal to 92% and the temperature was less than 100.4 F, a call was not required. The platform's dashboard displayed alerts when patients did not make their records or were not within the acceptable range. If they were the latter, the medical staff contacted the patient to conduct telephone follow-up or refer them to an emergency. 225 patients were registered in the program; the results showed that there were 11% of patients registered a temperature above the range of 100.4, which was reflected in the alerts. Most patients did not require a telephone intervention during the entire process, managing only to maintain the intervention through the application. It shows that discharged patients can be monitored remotely without needing face-to-face care in the hospital and with less admission to the emergency department. Patient management can have a better experience by applying a platform that allows them to actively participate in their treatment and make decisions based on their health. The study is related to research because it was possible to demonstrate that remote monitoring of patients with COVID-19 is possible; however, further study is required to detect other variables.

3. Methodology

For the development of the following research work, the agile Scrum methodology was chosen because it uses an iterative and incremental strategy; that is, it encompasses a set of tools and functions that are synchronized and that help teams to structure and manage progress, risk control and the future vision of the project [15].

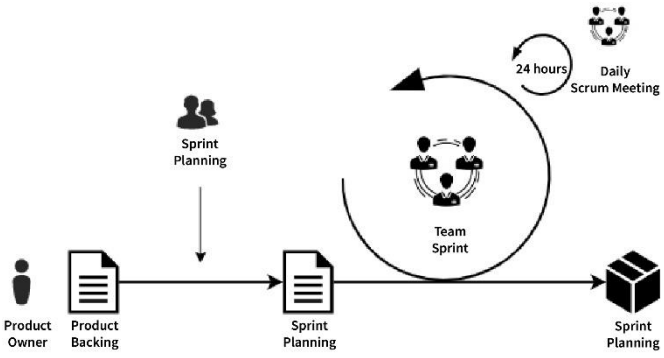

Fig. 1 Scrum's elements.

3.1. Scrum

3.1.1. Scrum Team

Scrum recommends that a maximum of ten members organize the team. In case the project is very extensive, the team should be restructured into small groups in order not to hinder communication between them [16].

The Scrum Team: is defined as a team of multidisciplinary people who oversee giving value to a Sprint. These are made up of the following:

Scrum Master: has the main function of aligning the team with the good practices proposed by SCRUM.

Product Owner: a single person who fulfills the role of being able to organize and prioritize the sprints contained in a backlog to increase the value of the product.

Development Team: they are a small group of professionals in charge of planning and executing the tasks to meet the Sprint objective.

3.1.2. Sprint

Sprints correspond to a set of work blocks, usually lasting from one to four weeks. There are four important moments in Scrum: Sprint Planning Meeting, Daily Scrum, Sprint Review, and Sprint Retrospective [16].

3.1.3. Artifacts

Scrum has defined a set of necessary artifacts so that everyone within the Scrum Team can concisely acquire crucial information about the project. These artifacts are as follows:

Product Backlog: The list of all the product's requirements or updates.

Sprint Backlog: It is a group of activities planned by the Development Team with the purpose that they can meet the Sprint objective. It can vary over time with improvements agreed upon in the Daily Scrum.

Product Increment: A small addition that generates value to the final product. All the increments must have completed status for the sprint to be released.

3.2. Scrum Stages

3.2.1. Definition of the Scrum Team

In the first phase, the formation of the Scrum Team is carried out. Likewise, User Stories are collected, and the general needs of the product are identified.

3.2.2. Product Backlog Management

In the second phase, the Product Backlog is defined, and the requirements are filtered and prioritized with the stakeholders.

3.2.3. Sprint Planning

In the third phase, the Sprint planning meeting will be held to define the Sprint Backlog based on the Product Backlog. These are lists of tasks that must be executed to

complete the customer's requirement. The execution of each task will oversee by the Development Team.

3.2.4. Sprint Development

In the fourth phase, the tasks of each sprint are developed, holding short daily meetings where the most important aspects of the progress of the tasks are reviewed. As a result, the status in the Sprint Backlog diagram is updated. Upon completion of the tasks, the Development Team displays the Sprint Product Increment to the entire Scrum Team, tests it against the acceptance criteria, and is either Denied or Accepted. This process is performed for each sprint of the project.

3.3. Software Development Tools

3.3.1. Dart programming Language

It is a programming language based on the C language and was created by Google, wanting to have a better programming language than JavaScript for developing web applications. Its main advantage is that it can work on different platforms with the same source code [17].

3.3.2. Flutter Framework

Flutter is a Framework that uses the Dart language. Flutter allows you to develop natively compiled mobile, web, and desktop applications from a single source code. The main advantages of Flutter are reduced development time with the Hot Reload feature, which allows you to see your source code changes instantly, either on an emulator or a physical device; the wide library of UI Widgets that it offers and can be fully customized; Finally, it preserves the performance of a native application by being able to compile the Source code natively [20].

3.3.3. PHP Programming Language

It is a high-level open-source language; it can be used on the server side, for example, in REST API services, and on the client side, for the construction of web pages [22].

3.3.4. Model-View-Controller (MVC) pattern

It is one of the most used patterns for structure when writing software code. The software is divided into three layers: Model, which corresponds to the abstraction of the entities, their processes, and the manipulation of their attributes; View is the visual part of the software; Controller, which is the layer in charge of the communication and coordination between the View and the Model [25].

3.3.5. Laravel Framework

Laravel is the most popular Framework of the PHP programming language since it has a flat learning curve [23]. It is based on the MVC pattern, although it adds more components such as routes, middleware, and policies. It is mainly used on the server side; however, it has a template engine called Blade for the client side.

3.3.6. Code editor Visual Studio Code

It is a cross-platform code editor that offers a graphical interface to edit source code in most programming languages. It is normally used by software developers [18].

3.3.7. IDE PHP Storm

It is an integrated development environment focused on the PHP language, which makes it easy for the developer to write code using keyboard shortcuts, pre-established functionalities, and execution of unit tests, among other features [24].

3.3.8. MySQL database

MySQL is a relational database management system. It was developed by Michael (Monty) Widenius (founder of MySQL) and the community of free software developers [19].

3.3.9. Miro

Miro is an online collaborative tool that allows you to work on prototypes of mobile and web applications; in turn, it has a wide range of elements, including icons, shapes, and templates.

3.4. Solution Architecture

The architecture encompasses all the main components of the system [21], whether they are physical, such as servers and access points, or logical, such as algorithms. The solution's architecture comprises a server where the REST Api services for the mobile application for post-Covid-19 patients and the web service for health personnel will be exposed through two subdomains. All process information will be stored in MySql, a relational database management system.

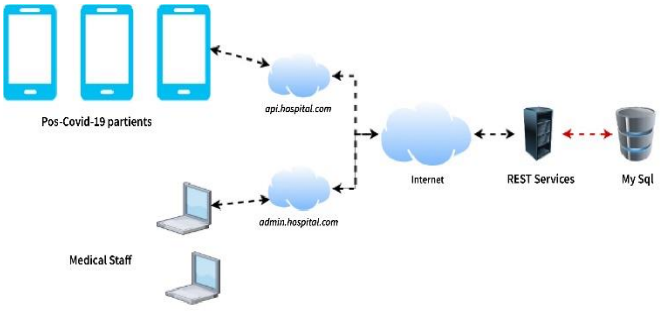

Fig. 2 Solution architecture

3.5. Solution Development

3.5.1. Definition of the Scrum Team

The following table specifies the roles of the Scrum Team with their respective managers (Table 1). Likewise, the User Stories (Table 2) of all the project stakeholders are collected.

Table 1. Scrum Team

Role	Abbreviation	Names and surnames
Scrum Master	SM	Laberiano Matias Andrade Arenas
Product Owner	PO	Miguel Angel Cano Lengua
Development Team	DT	Jean Carlo Palomino Gonzales

Table 2. User Stories

Role	Abbreviation
Patient	As a patient, I need to be able to consult medical staff remotely.
	As a patient, I need my personal health information protected from public disclosure or access.
	As a patient, I need to be informed of the latest News and recommendations for treating post-Covid-19 patients.
Medical Staff	As a medical staff, I need to know basic triage data to diagnose a patient.
	As a medical staff, I require a communication channel to contact the patient.
	As a medical staff, I need to send forms to the patient without needing them to visit the health center personally.
	As a medical staff, I need to be able to generate forms and assign them to users.
	As a medical staff, I need to view each user's daily triage data.
	As a medical staff, I need to see the form responses of each user.
	As a medical staff, I need to see statistics and the complete history of the user.

3.5.2. Product Backlog Management

With the collected User Stories, the Scrum Team and the stakeholders define and assign a priority (Table 3) to the project requirements and manifest it in a document, Product Backlog (Table 4).

Table 3. Priority Level

Level	Description
1	High
2	Medium
3	Low

3.5.3. Sprint Planning

With the defined Product Backlog, you can start structuring the Sprints (Table 5) that will be carried out during the project, specifying each one with its list of tasks, duration time, and the person in charge of the Development Team who will oversee each task and the Sprint (Table 6, 7, 8 and 9).

Table 4. Scrum Team

Code	Requirement	Priority
US-1	As a patient, I need to be able to consult medical staff easily.	2
US-2	As a patient, I need my personal health information protected from public disclosure or access.	3
US-3	As a patient, I need to be informed of the latest News and recommendations for treating post-Covid-19 patients.	1
US-4	As a medical staff, I need to know basic triage data in order to diagnose a patient.	3
US-5	Como personal médico, necesito enviar formularios al paciente sin necesidad de que se acerque personalmente al centro de salud.	3
US-6	As a medical staff, I need to be able to generate forms and assign them to users.	3
US-7	As a medical staff, I need to view each user's daily triage data.	3
US-8	As a medical staff, I need to see the form responses of each user.	3
US-9	As a medical staff, I need to see the complete history of the user.	2

Table 5. Sprints

Sprint	User Stories	Duration
Sprint 1	US-2, US-3	8 days
Sprint 2	US-1, US-4	16 days
Sprint 3	US-5, US-6, US-8	12 days
Sprint 4	US-7, US-9	7 days

Table 6. Sprint 1 Tasks

Task	Duration	Owner
REST API to authenticate patient	1 day	Jean C. Palomino
REST API to load data on Welcome Page	1 day	
Login Page UI	1 day	
Welcome Page UI	1 day	
Use of API REST to authenticate the patient in the App	1 day	

Table 7. Sprint 2 Tasks

Task	Duration	Owner
REST API To list News about Covid-19	1 day	Jean C. Palomino
News Page UI	1 day	
Use of API REST to list News in the App	1 day	

Table 8. Sprint 3 Tasks

Task	Duration	Owner
Set up Master Manager	1 day	Jean C. Palomino
Master Manager - Form Module	1 day	
Master Manager - Qualifications Module	1 day	
REST API to list user's forms	1 day	
REST API to store form responses	1 day	
REST API to view form	1 day	
Master Manager - Qualifications Module	1 day	Jean C. Palomino
Form List Page UI	1 day	
Form Questions Page UI	1 day	
Form User Responses Page UI	1 day	

Table 9. Sprint 4 Tasks

Task	Duration	Owner
Development of REST API for Daily Control Module	1 day	Jean C. Palomino
Daily Control UI	1 day	
Use of REST API to store daily control data	1 day	
Development of the User history Page in the master manager	1 day	

3.5.4. Development of each Sprint

This stage corresponds to developing the tasks defined in each sprint.

Sprint 1

In the development of Sprint 1, the Login screen will be developed, through which users will enter their patient profile, using their DNI and password to safeguard their data as a patient. You will also see a " News " module in the side menu, where you can access the latest publications and recommendations on Covid-19.

The prototypes of the Login Screen and News Screen screens (Figures 3 and 4) are the following:

Sprint 2

In the development of Sprint 2, the Welcome Screen (Figure 6) will be developed. The user will be able to see three sections: "My Forms," "Contact a Medical Personnel," and "Register my daily triage," in both, the latter will be the focus of this sprint.

In the "Register my daily triage" section, by clicking on the "Register self-control" button, the user will be able to register their triage data.

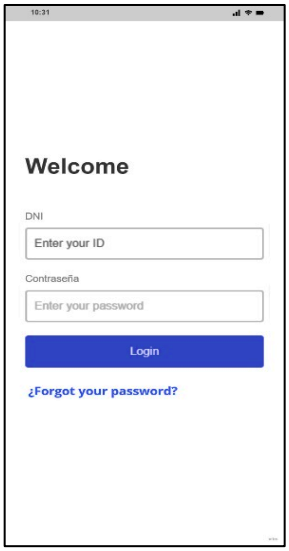

Fig. 3 Login Page

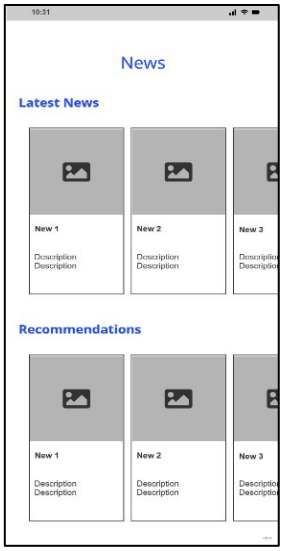

Fig. 4 News Page

In the "Contact" section, on the "See contact information" button, the user will enter a screen where they will find all the ways of contacting medical personnel. The "Contact" screen can also be accessed from the left-side menu (Figure 5).

Fig. 5 Side Menu

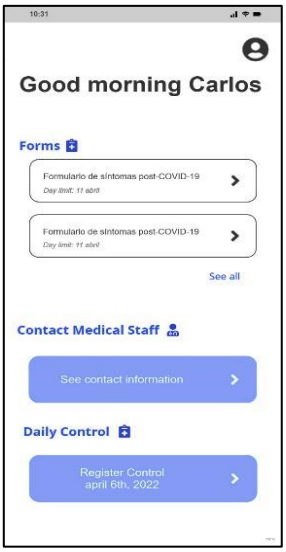

Fig. 6 Welcome Page

Sprint 3

In the development of Sprint 3, the Master Manager will begin to be developed, from which all the system's resources will be managed; users, forms, daily control records, and statistics. The Master Manager will consist of 4 modules: Patients, Form Management, Statistics, and Daily Control of Patients. In this sprint, start with the Patients and Forms modules.

Patient Module: It consists of the list, creation, editing, and updating of the data of each patient who has access to the application. It will also have the functionality of seeing the assigned forms and the daily control recorded for each patient (Figure 7).

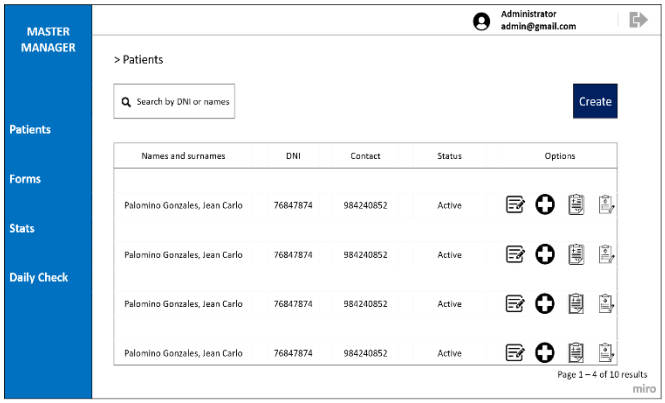

Fig. 7 Master Manager - Patients Module.

Forms Module: It consists of listing, creating, editing, and updating each form's data. It will also have the functionality of assigning each form individually or massively to each patient (Figure 8). On another screen, it will be possible to view all the responses to the selected form (Figure 9).

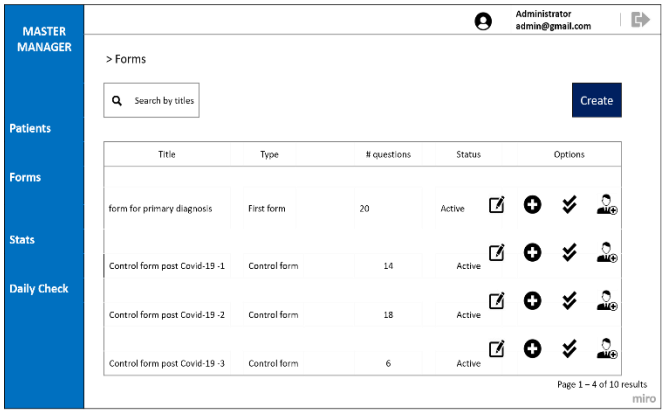

Fig. 8 Master Manager - Forms Module.

Fig. 9 Master Manager – Forms-Answers View.

Sprint 4

In the development of Sprint 4, the development of the Master Manager will continue with the Statistics and Daily Control of Patients modules.

Statistics Module: In the following module, a few statistical graphs are displayed that correspond to the post-Covid-19 stage of each patient. (Figure 10).

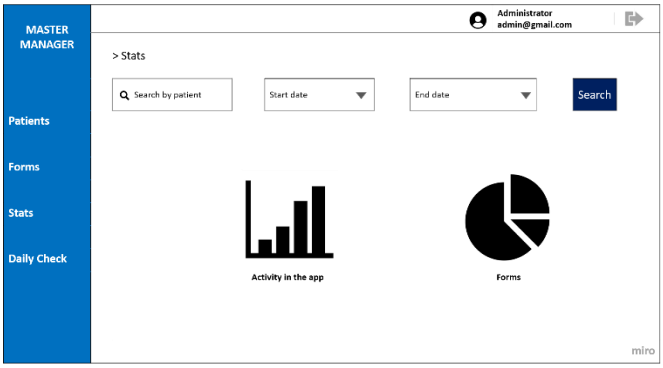

Fig. 10 Master Manager – Stats Module.

Daily Patient Control: In this module, you can see the daily data recorded by each patient (Figure 11).

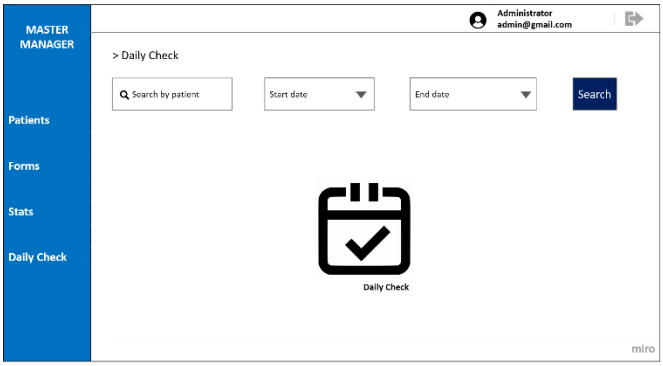

Fig. 11 Master Manager – Daily Check Module.

4. Results

4.1. Validation by Expert Judgment

The tool, Expert Judgment was used to measure the results. Five specialists were contacted, three from technology and two from health. Using the prototypes presented, the experts judged under five criteria: usability, scalability, technology, feasibility, and innovation, rating from 1 to 10, with 10 being the highest score and 1 the lowest, the Mobile Application and the Master Manager (Table 10).

Obtaining an average above 88% in all the criteria, proving that implementing the multiplatform mobile application optimizes the management of post-Covid-19 patients.

Table 10. Expert judgment

Criterion	Jurors				
	1	2	3	4	5
Usability	90%	80%	90%	90%	90%
Escalability	90%	90%	100%	90%	80%
Technology	90%	90%	90%	80%	80%
Feasibility	80%	90%	80%	90%	90%
Innovation	90%	90%	100%	90%	90%

Table 11. Results

Task	Average	Satisfaction
Usability	88%	Media
Escalability	90%	Media
Technology	86%	Media
Feasibility	86%	Media
Innovation	92%	High
Average	**88.4%**	**High**

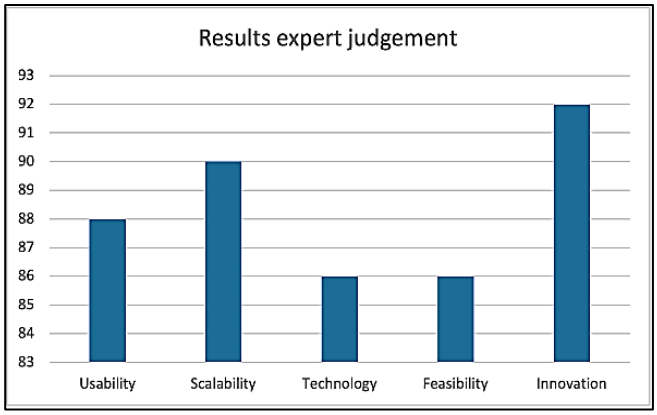

Fig. 12 Results expert judgment

4.2. About the Methodology

After evaluating the current situation of the problem, the development of a mobile application has been proposed that allows remote management of post-COVID-19 patients, as well as home monitoring of patients who were discharged from the national hospital. Considering that the current pandemic is taking place in a changing context, the mobile application that now calls a product; must be carried out under an agile methodology in such a way that it allows adapting to continuous changes throughout the process. In an analysis carried out by [32], they compare different methodologies for developing IT projects, of which two methodologies stand out, Kanban and SCRUM. The characteristics evaluated were the man-hours used and the management cost, expressed in rubles (0.057 soles). The results of applying the method of choosing the project management methodology are based on labor and management cost (Table 12).

As can be seen, the two methodologies that provide a lower amount of cost and labor are both SCRUM and Kanban; therefore, a comparison of the benefits of each of them was made again, obtaining the following table. (Table 13).

Table 12. Comparison of methodologies

	Project features	
Methodology	**Labor input Man-hours**	**Management cost in thousand rubles**
SWEBOK	2,435	1,059.50
PMBOK	2,260	1,020.00
PRINCE2	2,150	921.50
P2M	1,385	627.25
Kanban	540	249.25
SCRUM	435	201.75

Table 13. Methodology selection

Methodology	Indicators	Indicator value
Kanban	Profit, thousand rubles	1,311.50
	Expenses (cost of the project), thousand rubles	729.25
	Tiempo de ejecución del proyecto, días	116
SCRUM	Profit, thousand rubles	1,311.50
	Expenses (cost of the project), thousand rubles	729.25
	Tiempo de ejecución del proyecto, días	116

As a result, the SCRUM methodology has greater cost benefits and does not have a longer execution time than its comparison. Therefore, using this methodology in developing the solution has been considered, being the best option in the face of changing requirements and for which flexibility and speed are needed.

4.3 Proposal for an innovative post-Covid-19 patient management model

As a result of the research, a model for managing post-Covid-19 patients is proposed (Figure 13). The model by the application begins with the login of the post-Covid-19 patient. On the home screen, you can view a summary or direct access to the "Forms," "Contact with medical personnel," and "Daily control record" and access the news section; you can do it through the side menu. The medical staff will be able to access all the information registered in the mobile application through the different modules.

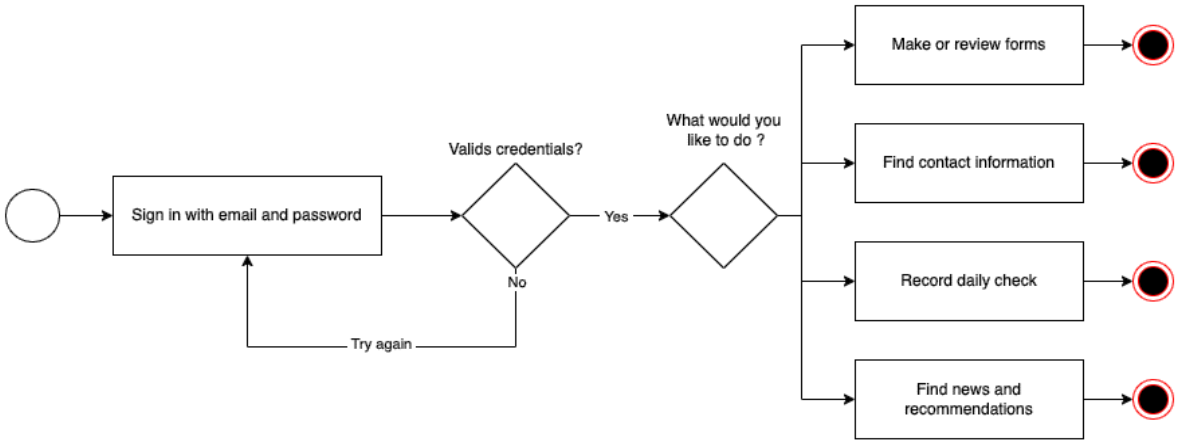

Fig. 13 Flowchart proposal for patients pos-Covid-19 management

5. Discussions

In harmony with the authors [9], [12], and [13], it is concluded that the implementation of a mobile application brings a series of benefits to a hospital, such as: being able to access patient data at all times, a more agile process for medical staff to perform all their tasks and support for senior management in decision making and strategy formulation. Along with the mobile application, see that the implementation of a web application (Master Manager) for the management of all the administrative processes necessary for the mobile application and health personnel complemented the benefits of the mobile application, as in the case of [10], who made use of both, web and mobile application, to provide a solution to remote care for older adults who have mobility impairment due to their illness, a situation very similar to that of post-Covid patients. 19, who due to health protocols must remain in isolation. Finally, using an agile methodology with the Scrum framework was the best option, thanks to iterative and incremental properties, which makes the development of the mobile application adapt perfectly to such a variable scenario, as is that of Covid-19. The authors [11] and [13] also opted for using an agile methodology with the Scrum framework in their respective situations. In addition, it is different from the methodologies carried out in their studies with the authors [27], [28], [29], [30].

6. Conclusion and Future Work

This research work aimed to develop a multiplatform mobile application for the management of post-Covid-19 patients. We have concluded that the development of a multiplatform mobile application reduces post-Covid-1 patient care times; The development of a multiplatform mobile application allows the continuity of care for post-Covid-19 patients. The model can also be adapted to care for other complications; The development of a multiplatform mobile application speeds up access to post-Covid-19 patient information. On the other hand, the limitation of the mobile application, it was found that health systems require reactions in real-time; however, the application will not be able to respond in this way, so it cannot have instant reactions, such as notifications, alerts, comments, responses, among others, that would help improve the patient experience and streamline the processes that will be carried out between the mobile and web application. Likewise, as future work, possible improvements are suggested in different sections of the Mobile Application and modules of the Master Manager, as the improvement opportunity in the Contact module. It is suggested to implement a Chat with the medical staff that is available 24/7; in this way, the availability of the health service can be guaranteed to a greater degree. Also, to centralize more services in the application, it is recommended to implement the call or videoconference functionality so that the medical personnel can carry out the respective telemedicine services, or failing that, integrate with a third party that provides the service, for example, Zoom. At the same time, it is suggested to streamline the processes of creating, updating, deleting, and changing the status of patient data and forms. For example, implement massive processes through files in .xlsx and .csv format or a REST API if you want to enter data from an external platform. Lastly, a module could be implemented to manage medications administered and prescribed to patients.

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