International Journal of Engineering Trends and Technology
ISSN: 2231 – 5381 / https://doi.org/10.14445/22315381/IJETT-V71I4P221

Volume 71 Issue 4, 238-255, April 2023

Original Article

Design of a Monitoring System for Hospitalized Patients Based on Early Warning Score

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Received: 19 January 2023 Revised: 18 March 2023 Accepted: 01 April 2023 Published: 25 April 2023

Abstract *- The purpose of this research is to design a Hospitalized Patient Monitoring (MPH) system based on the Modified Early Warning Score (MEWS) system that improves the response time of medical personnel in patient care at a health center in Metropolitan Lima in the year 2022. It is supported by the importance of monitoring the patient's health and the detection of alterations in their vital signs. Therefore, in the development, the MEWS system is used since it allows timely alerting of the patient's worsening, based on the assessment of the measurements of the vital signs that are obtained in the monitoring. On the other hand, the development methodology is based on the Scrum methodological framework, through which a total of 4 Sprints have been carried out, in which the research deliverables are presented. The results indicate that the use case diagram, the entity relationship diagram, the system architecture and the total modeling of the interfaces planned for the investigation are delivered. Likewise, the result of the design validation survey is evaluated using Cronbach's alpha, which gives a reliability coefficient of 0.892, called "Good" within the assessment scale. Thus, it is concluded that the analysis of the system requirements were achieved, the identification of the values of the vital signs measured in the patients in the MEWS system, the establishment of the patient's clinical history, the transfer of information, the referral of the case to the appropriate medical personnel for patient care. In addition, based on the information obtained from a survey, it was possible to record the optimization of the response time of medical personnel in patient care based on the design.*

Keywords *- Vital signs monitoring, SCRUM, Early warning system, MEWS.*

1. Introduction

At present, when you want to monitor a hospitalized patient, the measurement of some vital parameters is carried out directly, or they are obtained from a device to which the patient is connected. According to [1], 224,697 men and 647,516 women are hospitalized in Peru. Of which, [2] states that during 2018 a total of 221 deaths due to in-hospital mortality were registered in its facilities. Added to this, [3] considers that inadequate monitoring of vital signs could lead to an increase in the in-hospital mortality rate. In addition, [4] mentions that incorrect monitoring of the patient's health status triggers unplanned admission to an Intensive Care Unit (ICU).

On the other hand, in an investigation carried out by [5], an attempt has been made to carry out remote monitoring. However, this has not been convenient since if the doctor does not have a record of the patient's vital signs, as a result of the constant monitoring that is carried out, he cannot make an adequate decision to modify the treatment administered—the patient. Likewise, the difficulty in contacting the specialist in charge is highlighted since the doctor who monitors a certain patient is not always present and is often notified late. This leads to an increase in the risk of a patient's health deterioration because if a condition that needs to be treated urgently is detected when the specialist is not presently informed about its progress, they may receive late or suboptimal care.

The reason why arises as a research problem to what extent the design of a Monitoring System of Hospitalized Patients (MPH) based on the Modified Early Warning Scoring system (MEWS) improves the response time of the personnel doctor in the care of patients in a health center in Metropolitan Lima in the year 2022? Moreover, as specific problems, in what way do the necessary requirements for elaborating the design of a monitoring system optimize the response time of the medical personnel? What are the values of the vital signs measured in hospitalized patients through the MEWS system? Moreover, how is the patient's medical record established and transferred to the medical staff through the MEWS system?

In this sense, the research aims to design a Hospitalized Patient Monitoring (MPH) system based on the Modified Early Warning Score (MEWS) system that improves the response time of medical personnel in patient care in a health center of Metropolitan Lima in the year 2022.

2. Literature Review

Advances in technology in recent years have been supportive in health centers, implementing equipment, tools, laboratories, offices and studies, and creating information systems that contribute to monitoring patients and, therefore, the improvement of the decision-making of the health personnel in charge.

Designing an information system containing criteria, values and domains demonstrating good software quality in the medical field leads to greater benefits for health entities. According to [6], the application of an information system must be based on 7 inclusion criteria, such as governance; System design; system management; data management; data sources; results and quality of the data, since this allows an improvement in the efficiency of the work by medical personnel. In short, [7] considers that an information system must be aimed at collecting good quality data to be credible and coherent and supports the planning, monitoring and evaluation of resources that favor health managers. Thus, according to [6] and [7], adequate implementation of information systems aimed at the health field allows medical personnel to have additional resources to develop their activities based on high-quality information that generates better follow-up in patient care.

Consequently, having a system that allows monitoring of the progress of patients' health involves identifying in a timely manner when there is deterioration in their health to prevent their condition from worsening and requiring their admission to the ICU. For [4], one of the main reasons why a patient is transferred from a general hospital ward to the ICU is due to suboptimal care in the area, as a result of inadequate monitoring and evaluation of the state of health in which the patient is found. For this reason, [3] considers that identifying in time and responding to the patient's clinical deterioration leads to a decrease in the number of unplanned ICU admissions, a decrease in the number of patients suffering from unexpected cardiac arrests and even reduced hospital mortality rates.

In this sense, some systems have been implemented that allow adequate patient health monitoring. Given this, some authors have studied the feasibility of monitoring patients remotely through the use of indicators. According to [8], it is feasible to establish a set of parameters or indicators of a patient's well-being through a text messaging system to identify if there is progress or deterioration of health and, in such cases, carry out a medical intervention by telephone. In this regard, [5] observes that although the recording of a vital parameter helps to notify about the deterioration of health, it is not favorable for the doctor to carry out a remote follow-up of the patient's progress because there is a level Low confidence due to the insufficient number of results that allow health personnel to make a better decision about the treatment or medication that is administered to the patient. Thus, both authors believe that registering indicators in the software is necessary. It should be noted that [5] states that doctors require face-to-face monitoring since more information is obtained supporting decision-making about the patient's health.

Therefore, it is exposed that a rigorous patient follow-up is necessary to obtain a set of parameters that support the doctor's clinical decision. In this regard, [9] considers that having a multidisciplinary work team that controls and carries out the planned monitoring of the patient's health increases their quality of care since the support of clinical software that uses health management strategies of the population (PHM), favors the decisions made by the doctor during this entire stage of patient surveillance. In addition, [10] has determined that monitoring through a system integrated with electronic alerts is beneficial since it can help improve the doctor's behaviour through early detection of the lesion. Accordingly, [3] highlights the importance of implementing the EDCERS protocol in a health system. It integrates early detection of clinical deterioration, planned follow-up, and the use of care criteria to establish and identify the abnormalities in the patient's state of health. Likewise, it exposes the importance of a communication plan between the medical staff, for which it considers that using mobile phones and direct communication is beneficial when it is necessary to contact only one person. However, it highlights that it takes a long time to contact a whole team of specialists, and in such a case, a messaging system could provide a solution to the problem, but it has not yet been contemplated in the EDCERS protocol.

On the other hand, carrying out adequate monitoring to recognize changes in a patient's health contributes to improving the decision-making of medical personnel. For this reason, some authors believe that improving the clinical decision-making process requires that information systems have data that meets a certain quality and come from reliable sources to support their activities. Specifically, [11] affirms that having reliable data in an information system in the health sector is important because it contributes to providing effective management in their facilities since they facilitate the actions of the doctor and as a result of this, patients are able to access and receive better benefits in the monitoring services offered to them. In the same way, [12] considers that the most important thing is to have a reliable source of data-oriented to provide high-quality information for its usability in the clinical decision-making process. In summary, for [11] and [12], having good data quality is important in a medical

information system since it improves the orientation of medical personnel to opt for a better decision.

Finally, in view of what was stated by the authors, it was identified that not monitoring the patient's condition could cause health deterioration. Likewise, an effective communication plan is necessary when it is necessary to contact more than one specialist. In addition, taking into account the literature review, it is considered convenient that an information system contains indicators of vital parameters to carry out adequate monitoring of the state in which the patient is. In the same way, it is important to notify the medical specialist efficiently of detecting any anomaly and that he or she has the necessary quality information at all times to take better actions in the face of a worsening of the patient's health. Therefore, in the present investigation, the design of a monitoring system for hospitalized patients is elaborated that integrates the monitoring of vital signs in order to detect any anomaly or alteration in them, an early warning system that determines through the result score, the moment in which it is required to notify the specialist in charge of the patient and a communication plan that allows responding to the scores through notifications issued by the mobile application in order to shorten the communication time between medical personnel.

3. Methodology

For the development of the investigation, the referential framework Scrum is used, whose methodology stages are adapted to the present investigation.

Likewise, for the choice of the methodology, other investigations that make use of Scrum are taken into account, where important results were achieved to highlight. In the first place, according to [13], he obtained successful results in the development of a mobile application for post-Covid 19 patients after the use of the Scrum methodology, from which he expresses that compared to the Kanban methodology, Scrum has greater benefits regarding the financial cost and time of elaboration of a project.

Secondly, [14] managed in his research to boost sales through the construction of a virtual store developed under the Scrum methodology, which he considers to be easier to use than other methodologies and highlights that Scrum manages short cycles iteratively; they are called Sprint.

Third, according to [15,16], through the use of Scrum in his research, he was able to optimize sales in a Peruvian company through a mobile application; where he mentions that Scrum allows work to be divided into Sprints focused on meeting small objectives of the project in an agile way.

Fourth, in a similar way [29], he uses the Scrum methodology to achieve the creation of a mobile application that allows control and manage citizen security. In addition, his research highlights that Scrum is characterized by providing organization in software development and allowing changes that arise in the construction of applications to be managed.

On the other hand, according to [17], Scrum offers adaptability, flexibility, effectiveness, efficiency and teamwork within its characteristics. In addition, it allows the continuous improvement of the project because one of the most important points of Scrum is the Sprints. Added to this, [18] consider that the Sprint is the most important point of the Scrum methodology, from which the planning of the time of the activities, the review and the retrospective can be carried out. The following figure shows the stages of Scrum.

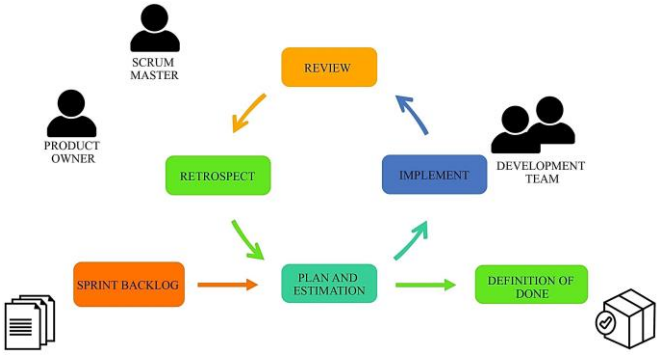

Fig. 1 Scrum stages

3.1. Scrum stages

3.1.1. Initiate

In the first place, [17] indicates that the initiation phase allows the creation of the project's vision through the business case review. In addition, in this phase, the Scrum Master and Stakeholder can be identified using defined selection criteria. Likewise, the Scrum team is formed, and the prioritized backlog of the product is prepared.

3.1.2. Plan and Estimation

After that, there is the planning and estimation phase. According to what was stated by [17], in this phase, we proceed to elaborate on the user stories, the acceptance criteria for each of them and the effort required to comply with detailed functionality is calculated. Likewise, the tasks for each user story (HU) are identified and estimated. The sprint backlog is created, including the tasks carried out in a certain sprint based on the sprint planning meeting, which is subsequently assigned to each team member.

3.1.3. Implement

On the other hand, [17] mentions that, in the implementation phase, the Scrum team performs the tasks established within the Sprint Backlog with the purpose of generating the deliverables required for a sprint. In addition, the team holds a meeting every day, known as the Daily

Standup. In this meeting, the tasks being completed are followed up, and the team is informed of obstacles and delays that arose during the activities. In addition, as a result of the team's progress, the Prioritized Product Backlog is constantly updated.

3.1.4. Review and Retrospect

In this review phase, [17] indicates that the team members present the deliverables corresponding to the Sprint to the Product Owner and stakeholders through a review meeting in order for the Product Owner to approve the sprint deliverables. Likewise, [15] highlights regarding the retrospective that the team meets with the Scrum Master to analyze all the lessons learned during the Sprint preparation, allowing them to improve the preparation of subsequent sprints.

3.1.5. Release

Finally, in the launch phase, according to [17], the deliverables approved by the Product Owner are presented to the stakeholders. A document is prepared that supports the satisfactory fulfillment of the Sprint. Likewise, a product retrospective is carried out, allowing the lessons learned to be identified and applied later in other projects.

3.2. Development Tools

3.2.1. Figma

According to [19], Figma is defined as a web tool focused on the design of User Interface (UI) and User Experience (UX) for the creation of application interfaces. Likewise, [20] adds that compared to tools such as Sketch or Adobe XD, Figma offers its users a better experience during the interface design process since the structure of its web page is clear and concise. In the investigation, the tool allows showing all the elements that each module has with which the medical personnel interact in a mobile environment to have an overview on the screen of the functionalities provided by the application.

3.3. Methodology Development

It is considered necessary to describe the development of the methodology used in the investigation, so the use of each of the phases of the SCRUM methodology in the development of the investigation is explained in detail.

3.3.1. Initiate

Roles

The members of the team of the present investigation are designated to fulfill the roles according to their abilities and capacities; likewise, the authors take into account teamwork as one of the advantages that Scrum presents, where the commitment of each member to help each other is considered. to solve problems that may arise in the development of their activities. Regarding the designation of roles, the authors define Miguel Ángel Cano Lengua as a Scrum Master since he has the necessary experience in managing work teams, contributing to improvements in projects and can address any barrier that prevents the team from achieving its goals. Sprint goals. Likewise, the research authors designate Luis Carmelo Rada Mota for the role of Product Owner because he has the adequate skills to carry out requirements gathering and is in charge of communicating the product's vision to the development team. Finally, María Antonella Aguirre Méndez and Renzo Jesús Valdivia Gómez play the role of the development team since they have the experience required to carry out the design of the mobile application.

Table 1. Scrum team

Role	Names and Last Names
Scrum Master	Miguel Ángel Cano Lengua
Product Owner	Luis Carmelo Rada Mota
Development team	- María Antonella Aguirre Méndez - Renzo Jesús Valdivia Gómez

Users

According to the research objective, the authors establish the medical personnel as users who interact with the design to be developed, specifically those who occupy one of the positions in the following table, shown in order of relevance.

Table 2. Types of users

Users
Titular doctor
Medicine resident
Medicine intern
Nurse
Nursing technician

Requirements Analysis

According to the interview carried out, the following table shows the functional requirements of the system on which the research design is based. There are a total of 13 functional requirements, to which an identifier with the initials FR was assigned.

Table 3. Functional requirements

ID	Functional Requirements
FR1	User registration
FR2	User login
FR3	View user profile
FR4	Patient registration
FR5	Patient history registration
FR6	View patient history
FR7	Attention registration
FR8	Patient list
FR9	Patient monitoring
FR10	Monitoring list
FR11	Hospital progress report
FR12	Medical alert
FR13	Communication between medical personnel

Table 4. Non-functional requirements

ID	Non-Functional Requirements
NFR1	The response time of the system must be at least 5 seconds.
NFR2	The system must be able to operate properly with multiple users simultaneously.
NFR3	The system must have intuitive graphical interfaces.
NFR4	The information recorded by users must be maintained in an integrated manner.
NFR5	The system must be compatible with Android mobile devices.

Likewise, as a result of the interview carried out, 5 non-functional requirements of the system are established, to which an identifier with the acronym NFR is assigned.

3.3.2. Plan and Estimation

User Stories

For the elaboration of the user stories, the requirements obtained from the system are considered, described in the previous point. Likewise, each HU has a brief description, an observation if necessary, and criteria such as:

- Business Priority: The measurement for business priority is defined at the High, Medium, and Low levels

- Development importance: The product owner and the development team independently assign a score from 1 to 10, after which the results are added to establish the importance value.

- Estimation time: The time required to implement the user stories is estimated according to the total time available to carry out the investigation.

The UH01 is named "User registration", the established priority is "High", the score given by the product owner for the importance of development is 10, and the score given by the development team is 9, with which it is obtaining a total of 19 points for the importance of development. In addition, the estimated time for the preparation of the HU is 1 day. The table below contains the complete detail of the UH01.

The UH02 is named "User login", the established priority is "High", the score given by the product owner for the importance of development is 9, and the score given by the development team is 8, with which it is obtained a total of 17 points for the importance of development. In addition, the estimated time for the preparation of the HU is 1 day. The table below contains the complete detail of the UH02.

The UH03 is named "User Profile", the established priority is "Low", the score given by the product owner for the importance of development is 2, and the score given by the development team is 3, with which A total of 5 points are obtained for the importance of development. In addition, the estimated time for the preparation of the HU is 1 day. The table below contains the complete detail of the UH03.

Table 5. UH01

UH	
Name: User registration	
ID: UH01	Priority in the business: High
Importance of development: 19	Estimated time (days): 1
Description: As medical personnel, I am required to register in the application.	
Observations: The interface should allow the selection of the role and speciality of the medical personnel.	

Table 6. UH02

UH	
Name: User login	
ID: UH02	Priority in the business: High
Importance of development: 17	Estimated time (days): 1
Description: As medical personnel, I need to log in to the application.	
Observations: Access to the application must be through the corporate e-mail.	

Table 7. UH03

UH	
Name: User profile	
ID: UH03	Priority in the business: Low
Importance of development: 5	Estimated time (days): 1
Description: As medical personnel, I need to have a user profile.	
Observations: The interface must allow user data to be updated.	

Table 8. UH04

UH	
Name: Patient registration	
ID: UH04	Priority in the business: High
Importance of development: 16	Estimated time (days): 2
Description: As medical personnel, I need to record general patient information.	
Observations: The interface must allow the registration of the patient's age and address, among other data.	

Table 9. UH05

UH	
Name: Patient history registration	
ID: UH05	Priority in the business: Medium
Importance of development: 10	Estimated time (days): 1
Description: As medical personnel, I need to record the patient's medical information.	
Observations: The interface should allow the recording of pathological antecedents, allergies, medications, weight and height.	

Table 10. UH06

UH	
Name: View patient history	
ID: UH06	Priority in the business: Medium
Importance of development: 8	Estimated time (days): 1
Description: As medical personnel, I need to visualize the patient's medical history.	
Observations: The interface should allow viewing of the patient's medical history and access to patient attention.	

The UH04 is named "Patient Record", the established priority is "High", the score given by the product owner for the importance of development is 8, and the score given by the development team is 8, with which A total of 16 points are obtained for the importance of development. In addition, the estimated time for the preparation of the HU is 2 days. The table below contains the complete detail of the UH04.

The UH05 is named "Patient History Record", the established priority is "Medium", the score given by the product owner for the importance of development is 5, and the score given by the development team is 5, which is obtained for the importance of developing a total of 10 points. In addition, the estimated time for the preparation of the HU is 1 day. The table below contains the complete detail of the UH05.

The UH06 is called "Viewing the patient's history"; the established priority is "Medium", the score given by the product owner for the importance of development is 5, and the score given by the development team is 3, with which obtained for the importance of developing a total of 8 points. In addition, the estimated time for the preparation of the HU is 1 day. The table below contains the complete detail of the UH06.

The UH07 is named "Patient Care Record", the established priority is "Medium", the score given by the product owner for the importance of development is 5, and the score given by the development team is 4, which is obtained for the importance of developing a total of 9 points. In addition, the estimated time for the preparation of the HU is 1 day. The table below contains the complete detail of the UH07.

Table 11. UH07

UH	
Name: Patient attention registration	
ID: UH07	Priority in the business: Medium
Importance of development: 9	Estimated time (days): 1
Description: As medical personnel, I need to record information on each patient's attention.	
Observations: The interface must allow the recording of reason, diagnosis and treatment.	

Table 12. UH08

UH	
Name: Patient list	
ID: UH08	Priority in the business: Low
Importance of development: 7	Estimated time (days): 2
Description: As medical personnel, I need to visualize the list of patients I need to see.	
Observations: The interface must allow access to the general list of patients who are hospitalized.	

The UH08 is named "Patient List", the established priority is "Low", the score given by the product owner for the importance of development is 4, and the score given by the development team is 3, with which A total of 7 points is obtained for the importance of development. In addition, the estimated time for the preparation of the HU is 2 days. The table below contains the complete detail of the UH08.

The UH09 is named "Patient Monitoring", the established priority is "High", the score given by the product owner for the importance of development is 7, and the score given by the development team is 8, with which A total of 15 points are obtained for the importance of development. In addition, the estimated time for the preparation of the HU is 2 days. The table below contains the complete detail of the UH09.

The UH10 is named "Patient monitoring result", the established priority is "High", the score given by the product owner for the importance of development is 8, and the score given by the development team is 6, which is obtained for the importance of developing a total of 14 points. In addition, the estimated time for the preparation of the HU is 1 day. The table below contains the complete detail of the UH10.

The UH11 is named "Monitoring List", the established priority is "Low", the score given by the product owner for the importance of development is 4, and the score given by the development team is 3, with which A total of 7 points is obtained for the importance of development. In addition, the estimated time for the preparation of the HU is 2 days. The table below contains the complete detail of the UH11.

The UH12 is called "Patient progress report"; the established priority is "Low", the score given by the product owner for the importance of development is 3, and the score given by the development team is 3, which is obtained for the importance of developing a total of 6 points. In addition, the estimated time for the preparation of the HU is 2 days. The table below contains the complete detail of the UH12.

Table 13. UH09

UH	
Name: Patient monitoring	
ID: UH09	Priority in the business: High
Importance of development: 15	Estimated time (days): 2
Description: As medical personnel, I need to record the measurement of the patient's vital signs.	
Observations: The interface must have a button to record the values entered and calculate the patient's status.	

Table 14. UH10

UH	
Name: Patient monitoring result	
ID: UH10	Priority in the business: High
Importance of development: 14	Estimated time (days): 1
Description: As medical personnel, I need to visualize the outcome of the patient's condition and the staff's suggestions for attention.	
Observations: The interface should have a button to alert the suggested medical personnel.	

Table 15. UH11

UH	
Name: Monitoring list	
ID: UH11	Priority in the business: Low
Importance of development: 7	Estimated time (days): 2
Description: As medical personnel, I need to list all monitoring performed on the patient.	
Observations: The interface must have a date filter and allow access to the details of each monitoring.	

Table 16. UH12

UH	
Name: Patient progress report	
ID: UH12	Priority in the business: Low
Importance of development: 6	Estimated time (days): 2
Description: As medical personnel, I need to generate a report of patient monitoring by attention.	
Observations: The interface must allow filtering of the report by date.	

The UH13 is named "Alert to medical personnel", the established priority is "High", the score given by the product owner for the importance of development is 6, and the score given by the development team is 6, with what which is obtained for the importance of developing a total of 12 points. In addition, the estimated time for the preparation of the HU is 1 day. The table below contains the complete detail of the UH13.

Table 17. UH13

UH	
Name: Alert medical personnel	
ID: UH13	Priority in the business: High
Importance of development: 12	Estimated time (days): 1
Description: As medical personnel, I need to be alerted by the application when the patient's condition changes.	
Observations: The notification must allow access to patient information.	

The UH14 is called "Communication of medical personnel"; the established priority is "Medium", the score given by the product owner for the importance of development is 7, and the score given by the development team is 5, with what which is obtained for the importance of developing a total of 12 points. In addition, the estimated time for the preparation of the HU is 1 day. The table below contains the complete detail of the UH14.

Table 18. UH14

UH	
Name: Medical personnel communication	
ID: UH14	Priority in the business: Medium
Importance of development: 12	Estimated time (days): 1
Description: As medical personnel, I need to call the suggested personnel for patient attention.	
Observations: The application should allow sharing of patient information with the suggested personnel.	

Table 19. List of user stories

ID	Name	Priority	Importance	Estimated time (days)
UH01	User registration	High	19	1
UH02	User login	High	17	1
UH04	Patient registration	High	16	2
UH09	Patient monitoring	High	15	2
UH10	Patient monitoring result	High	14	1
UH13	Alert medical personnel	High	12	1
UH14	Medical personnel communication	Medium	12	1
UH05	Patient history registration	Medium	10	1
UH07	Patient attention registration	Medium	9	1
UH06	View patient history	Medium	8	1
UH08	Patient list	Low	7	2
UH11	Monitoring list	Low	7	2
UH12	Patient progress report	Low	6	2
UH03	User profile	Low	5	1

Table 20. Product backlog

Name	Priority	Importance	Estimated time (days)	Sprint number
Building the architecture of the mobile application	High	20	10	0
User registration	High	19	1	1
User login	High	17	1	1
Patient registration	High	16	2	1
Patient monitoring	High	15	2	1
Patient monitoring result	High	14	1	1
Alert medical personnel	High	12	1	2
Medical personnel communication	Medium	12	1	2
Patient history registration	Medium	10	1	2
Patient attention registration	Medium	9	1	2
View patient history	Medium	8	1	2
Patient list	Low	7	2	2
Monitoring list	Low	7	2	3
Patient progress report	Low	6	2	3
User profile	Low	5	1	3

User Stories in Order of Priority and Importance

The following table shows the total of the 14 user stories according to their priority and importance established in the tables prepared for each HU. Likewise, the estimated time in days for each of the stories is observed.

Table 21. Sprint 0 tasks

ID	Sprint Number	Tasks	Since	Until	Total days
TA01	0	Elaboration of the use case diagram.	7/10/2022	7/10/2022	1
TA02	0	Review of the use case diagram.			
TA03	0	Elaboration of the entity-relationship diagram.	8/10/2022	10/10/2022	3
TA04	0	Review of the entity-relationship diagram.			
TA05	0	Elaboration of the mobile architecture.	11/10/2022	13/10/2022	3
TA06	0	Review of the mobile architecture.			
TA07	0	Elaboration of the API architecture.	14/10/2022	16/10/2022	3
TA08	0	Review of the API architecture.			
Total			7/10/2022	16/10/2022	10

Table 22. Sprint 1 tasks

ID	Sprint Number	Tasks	Since	Until	Total days
TA09	1	Design of the user registration interface.	17/10/2022	17/10/2022	1
TA10	1	Review of the design of the user registration interface.			
TA11	1	Design of the user login interface.	18/10/2022	18/10/2022	1
TA12	1	Revision of the design of the user login interface.			
TA13	1	Design of the patient registration interface.	19/10/2022	19/10/2022	1
TA14	1	Review of the design of the patient registration interface.	20/10/2022	20/10/2022	1
TA15	1	Design of the patient monitoring interface.	21/10/2022	21/10/2022	1
TA16	1	Review of the design of the patient monitoring interface.	22/10/2022	22/10/2022	1
TA17	1	Design of the patient monitoring result interface.	23/10/2022	23/10/2022	1
TA18	1	Review of the design of the patient monitoring result interface.			
Total			17/10/2022	23/10/2022	7

Table 23. Sprint 2 tasks

ID	Sprint Number	Tasks	Since	Until	Total days
TA19	2	Design of the medical personnel alert interface.	24/10/2022	24/10/2022	1
TA20	2	Review of the design of the medical personnel alert interface.			
TA21	2	Design of the medical personnel communication interface.	25/10/2022	25/10/2022	1
TA22	2	Review of the design of the medical personnel communication interface.			
TA23	2	Design of the patient history registration interface.	26/10/2022	26/10/2022	1
TA24	2	Review of the design of the patient history registration interface.			
TA25	2	Design of the patient attention registration interface.	27/10/2022	27/10/2022	1
TA26	2	Review of the design of the patient attention registration interface.			
TA27	2	Design of the patient history view interface.	28/10/2022	28/10/2022	1
TA28	2	Review of the design of the patient history view interface.			
TA29	2	Design of the patient list interface.	29/10/2022	29/10/2022	1
TA30	2	Review of the design of the patient list interface.	30/10/2022	30/10/2022	1
Total			30/10/2022	30/10/2022	7

Table 24. Sprint 3 tasks

ID	Sprint Number	Tasks	Since	Until	Total days
TA31	3	Design of the monitoring list interface.	31/10/2022	31/10/2022	1
TA32	3	Review of the design of the monitoring list interface.	1/11/2022	1/11/2022	1
TA33	3	Design of the patient progress report interface.	2/11/2022	2/11/2022	1
TA34	3	Review of the design of the patient progress report interface.	3/11/2022	3/11/2022	1
TA35	3	Design of the user profile interface.	4/11/2022	4/11/2022	1
TA36	3	Review of the design of the user profile interface.			
Total			31/10/2022	4/11/2022	5

Product Backlog

The product backlog shown in the above tables are prepared based on the user stories defined and the priority, importance, and estimated time criteria. Likewise, the sprint number in which each story is implemented is defined at this point.

3.3.3. Implement

The estimated tasks for the implementation of each Sprint are described below in each table, considering the time in days it takes to complete each of the tasks.

Sprint 0

Sprint 0 includes the preparation of diagrams and architecture of the system. For this, there is a total of 8 tasks that are carried out from October 7 to October 16, comprising a total of 10 days. The following table shows the detail of the tasks assigned for the Sprint.

Sprint 1

Sprint 1 comprises user stories UH01, UH02, UH09, and UH010. To carry out the Sprint, there is a total of 10 tasks that are carried out from October 17 to October 23, comprising a total of 7 days. The following table shows the detail of the tasks assigned for the Sprint.

Sprint 2

Sprint 2 comprises user stories UH13, UH14, UH05, UH07, UH06, and UH08. To carry out the Sprint, there are a total of 12 tasks that are carried out from October 24 to October 30, comprising a total of 7 days. The following table shows the detail of the tasks assigned for the Sprint.

Sprint 3

Sprint 3 comprises user stories UH11, UH12, and UH03. To carry out the Sprint, there is a total of 6 tasks that are carried out from October 31 to November 4, comprising a total of 5 days. The following table shows the detail of the tasks assigned for the Sprint.

4. Results

The research results are focused on the deliverables each Sprint obtained and the interface design validation.

4.1. Sprint 0

4.1.1. Use Case Diagram

The diagram comprises 14 use cases defined according to the requirements established for the project in Table 3. In addition, the only actor related to the use cases is defined as the medical staff in the diagram, specifically under the user types described in Table 2.

4.1.2. Entity-Relationship Diagram

The diagram covers a total of 11 entities related to each other based on the previously established functional and non-functional requirements and the correct distribution of elements for the system design.

4.1.3. System Architecture

For the design of the research, the mobile architecture Model View Presenter (MVP) is used. According to [21], it is a software architecture pattern that provides a set of good programming practices and establishes a better project order by using 3 layers since it separates the logic from the user side and the business rules. The layers are called model, view and presenter, where the latter is the intermediary because it interacts more with the other layers. Likewise, [30] highlights the ease provided by the MVP pattern regarding the tests carried out on the software and the decoupling of its layers, which in turn facilitates maintenance and allows scalability over time for the development of new functionalities in the system.

In the "View" layer, a request is made from the Main Activity; it travels to the "Presenter" layer, which allows establishing communication between the "View" and "Model" layers, and then the request travels to the "Model" layer. , it has the Interactor that receives the request from the Presenter and sends it to the Repository, where the connection with the API is established.

On the other hand, the architecture under which the API is designed is called clean architecture, or onion architecture, because contiguous layers characterize it.

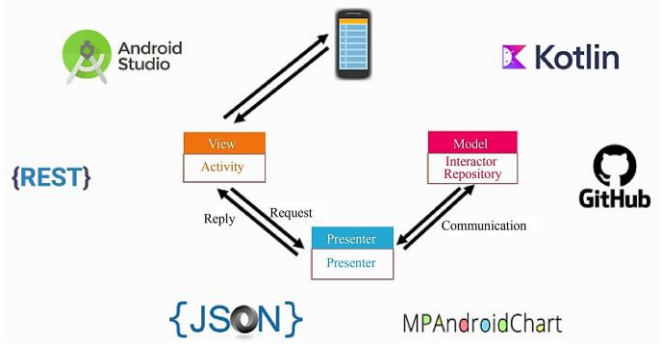

Fig. 2 Mobile architecture

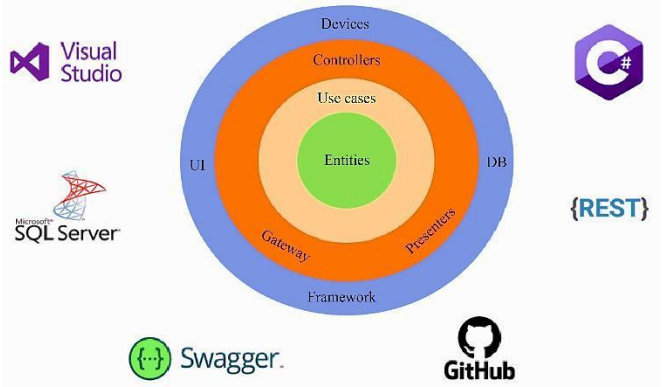

Fig. 3 API architecture

The authors [23] mention that the architecture uses the dependency rule, where the internal layers do not communicate with the external layers; however, the external layers use and depend on the internal layers. In addition, using the software architecture allows the code to be structured in independent layers, making it more readable and easy to maintain for large solutions since having a clean code causes multiple development groups to interact with the same solution. Independently compared to other architectures, that can get complicated due to dependent work.

4.1.4. Retrospect

Table 25. Sprint 0 retrospect

What went well in the interaction? (successes)	What did not go well in the interaction? (errors)	What could be improved in the next interaction? (recommendation for continuous improvement)
Conformity was obtained in the elaboration of the entity-relationship diagram and system architecture.	The use case diagram was not properly reviewed, so some cases were omitted, and the diagram had to be readjusted.	Consideration is given to performing thorough review tasks for sprint development.

4.2. Sprint 1

4.2.1. Design of the User Registration Interface

For the preparation of TA09, the "User Registration" interface is presented according to the description and observation of UH01. In the interface, medical personnel can create a user that allows them to interact with the system's functionalities.

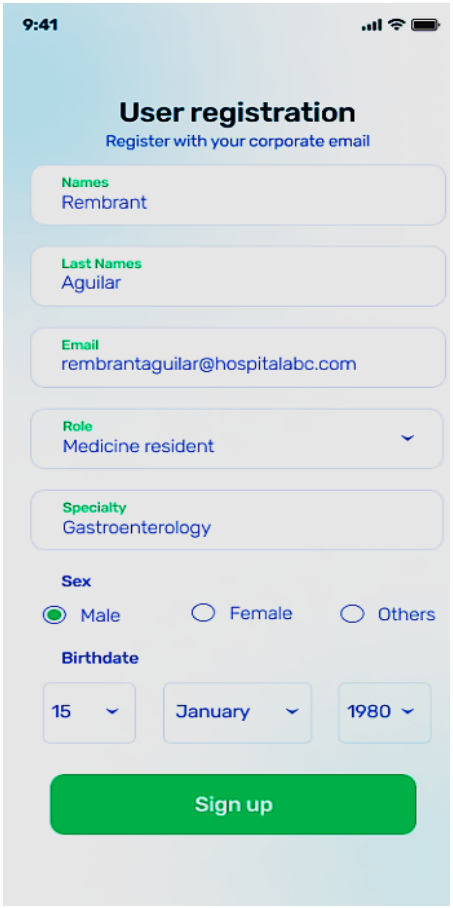

Fig. 4 User registration interface

4.2.2. Design of the User Login Interface

The "User Login" interface is presented as part of the development of TA11, according to the description and observation of UH02. In the interface, medical personnel can log into the system through corporate e-mail, which allows them to enter the system.

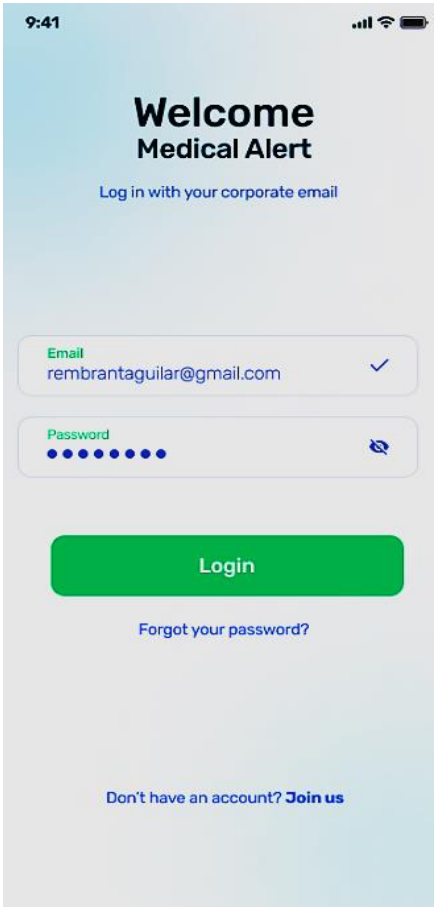

Fig. 5 User login interface

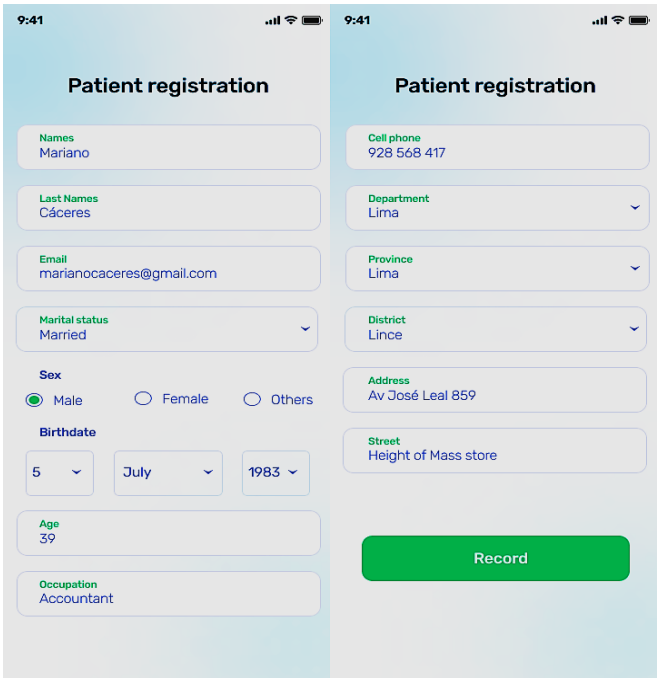

Fig. 6 Patient registration interface

Fig. 7 Patient monitoring interface

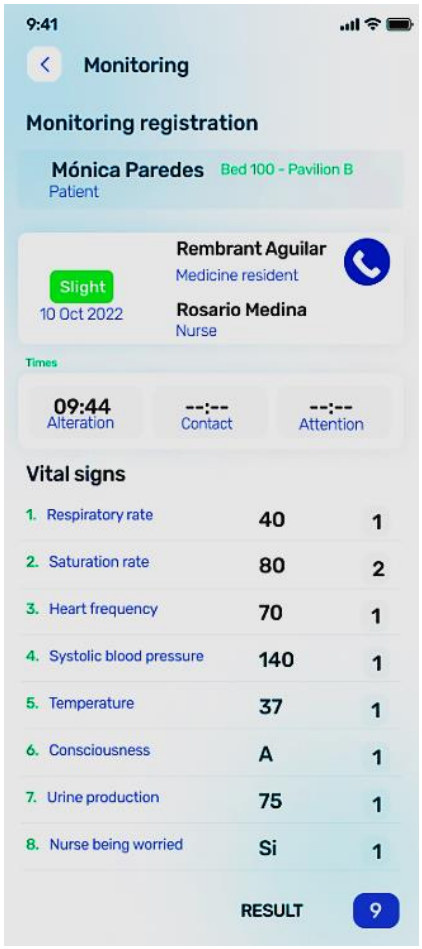

Fig. 8 Patient monitoring result interface

4.2.3. Design of the Patient Registration Interface

The "Patient Record" interface is presented as part of the preparation of TA13, according to the description and observation of UH04. In the interface, medical personnel can record the general data of a new patient.

4.2.4. Design of the Patient Monitoring Interface

Evidence of the modeling of the "Patient Monitoring" interface is shown as part of the development of TA15, according to the description and observation of UH09. In the interface, medical staff can record the measurement of the patient's vital signs and press the “Record monitoring” button to calculate the status of the hospitalized patient.

4.2.5. Design of the Patient Monitoring Result Interface

The figure.8 shows evidence of the modeling of the "Patient monitoring result" interface as part of the elaboration of the TA17, according to the description and observation of the UH10. In the interface, medical personnel can view the score assigned to each previously recorded vital sign and the total sum of these scores. In addition, the name of the medical personnel suggested for patient care and a blue button that allows communication with the personnel are displayed.

4.2.6. Retrospect

Table 26. Sprint 1 retrospect

What went well in the interaction? (successes)	What did not go well in the interaction? (errors)	What could be improved in the next interaction? (recommendation for continuous improvement)
Compliance was obtained in developing the interfaces in Figma for the user stories UH01, UH02, UH09 and UH010. In addition, the values set as examples in the interfaces are highlighted to understand the users better.	The description of the input fields was not established in elaborating the system design. Therefore, a redesign had to be made to include the description in each field.	UI and UX analysis is considered for the development of the following prototypes.

4.3. Sprint 2

4.3.1. Design of the Medical Personnel Alert Interface

The figure 9 shows the modeling of the "Alert to medical personnel" that is part of the preparation of the TA19, according to the description and observation of the UH13. The design shows the notification received by the medical personnel suggested for patient care before the result of the patient's monitoring. The notification contains the name and symbol of the patient's condition according to its severity. When extending the notification, the "View" button is displayed, which allows access to the patient's information.

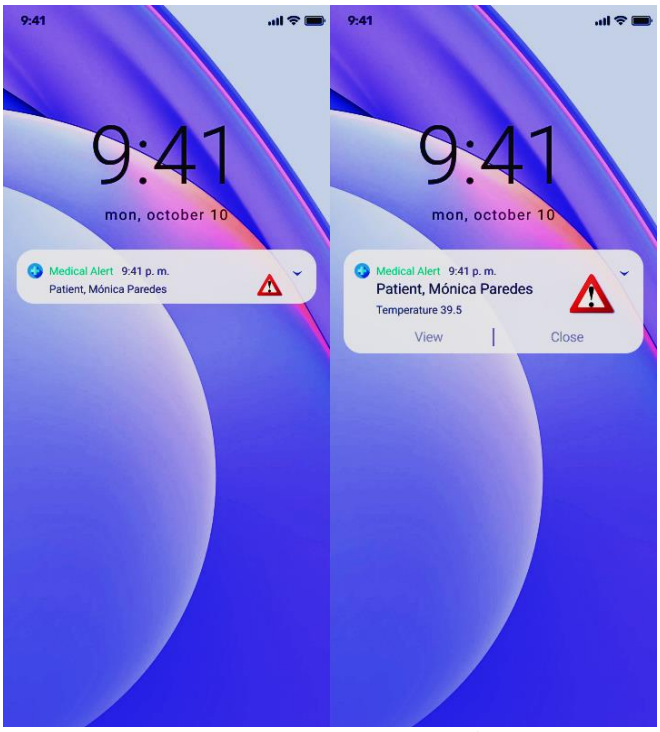

Fig. 9 Medical personnel alert interface

4.3.2. Design of the Medical Personnel Communication Interface

The figure 10 shows the modeling of the "Communication of medical personnel" interface, which is part of the development of the TA21, according to the description and observation of the UH14. After agreeing to provide care, the medical staff can view the measurement and score of the patient's vital signs on the screen. In addition, the interface allows access to the patient's history and, through the blue button, allows communication with the medical personnel who monitor the patient.

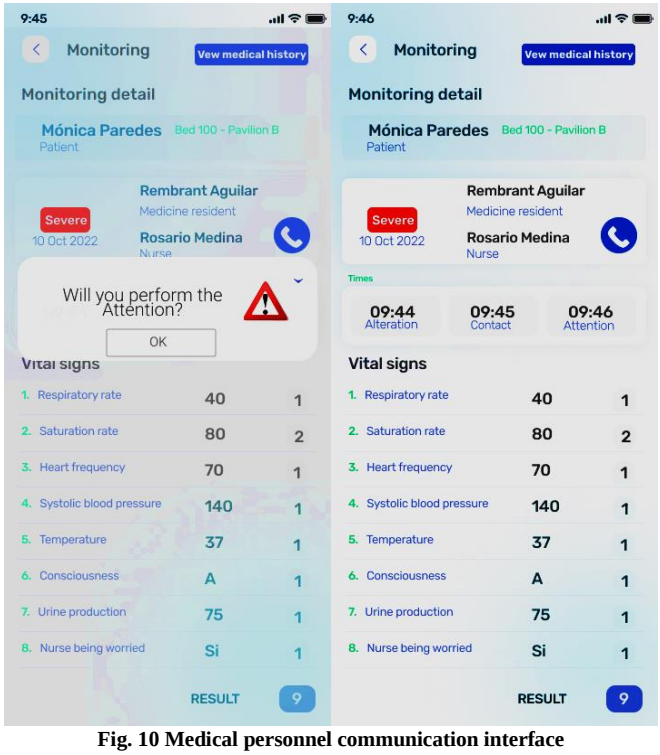

Fig. 10 Medical personnel communication interface

4.3.3. Design of the Patient History Registration Interface

The "Patient History" interface is presented as part of the preparation of TA23, according to the description and observation of UH07. In the interface, medical staff can record each patient's medical information. See figure 11.

4.3.4. Design of the Patient Attention Registration Interface

The figure 12 shows evidence of the modeling of the "Patient care record" interface as part of the development of TA25, according to the description and observation of UH07. In the interface, medical personnel can record the medical information of the care provided to the patient at the health center.

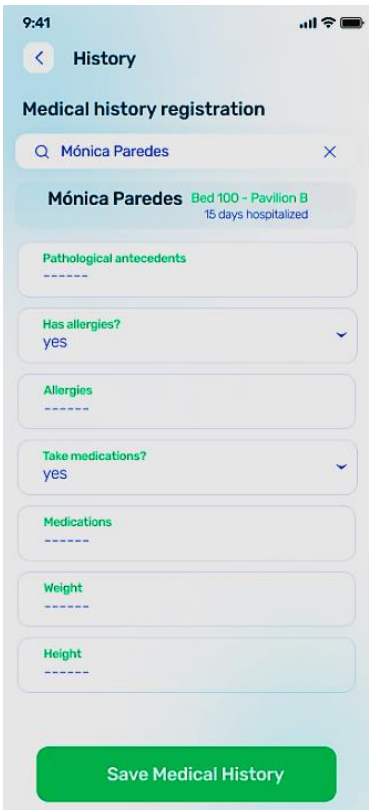

Fig. 11 Patient history registration interface

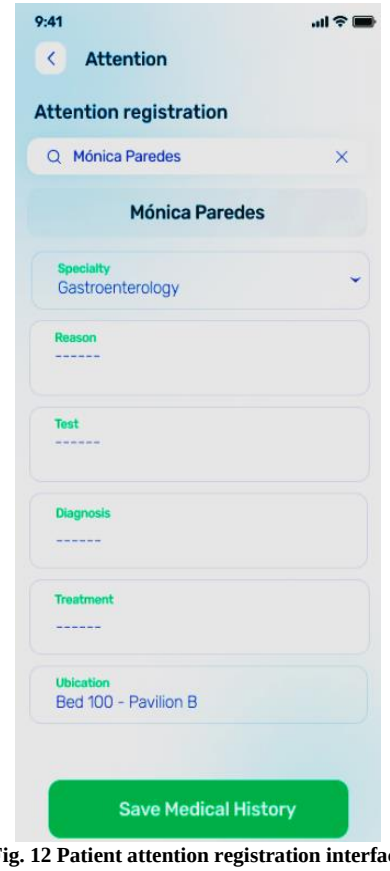

Fig. 12 Patient attention registration interface

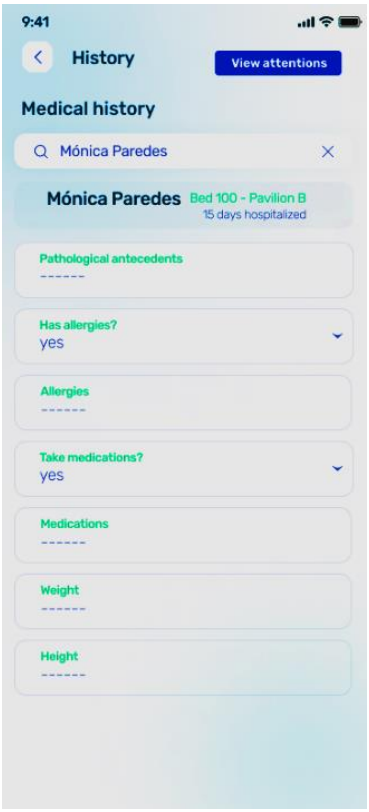

Fig. 13 Patient history view interface

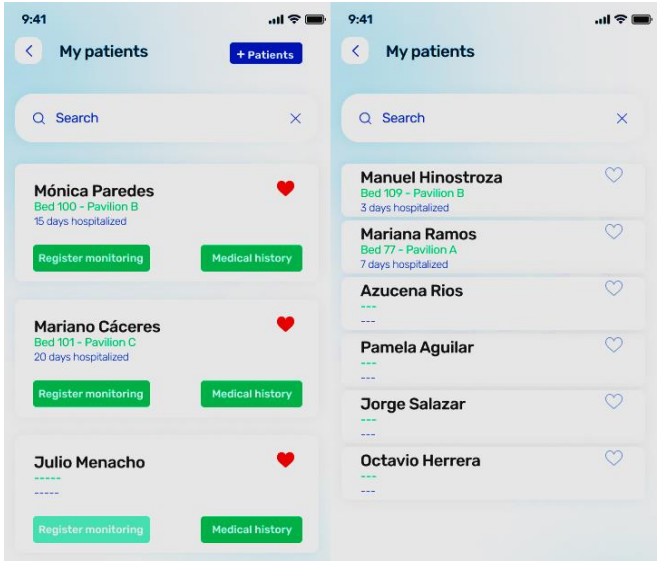

Fig. 14 Patient list interface

4.3.5. Design of the Patient History View Interface

The figure 13 shows the modeling of the "Patient history display" interface that is part of the development of TA27, according to the description and observation of UH06. In the interface, medical personnel can view the data recorded for the history. In addition, the interface allows, through the "see care" button, medical personnel to have access to information on all the care received by the patient at the health center.

4.3.6. Design of the Patient List Interface

The "Patient List" interface is presented as part of the preparation of TA29, according to the description and observation of UH08. The interface design allows medical staff to view their own patient list. In the event that the staff needs to add a new patient to their list, they must press the "+Patients" button that takes them to a general list of patients, allowing them to mark one or more patients they wish to add to their list.

4.3.7. Retrospect

Table 27. Sprint 2 retrospect

What went well in the interaction? (successes)	What did not go well in the interaction? (errors)	What could be improved in the next interaction? (recommendation for continuous improvement)
Compliance was obtained in developing the interfaces in Figma for the user stories UH13, UH14, UH05, UH07, UH06 and UH08. In addition, the filter at the top of the interfaces allows a direct patient search.	The lack of analysis for constructing interfaces was evidenced since not all the fields were available according to what was established in the database. Therefore, the design was restructured in order to have the missing fields.	It is considered to contrast the database model with the fields included in the interfaces.

4.4. Sprint 3

4.4.1. Design of the Monitoring List Interface

The following figure shows the design of the "Monitoring List" interface, which is presented as part of the development of TA31, according to the description and observation of UH11. The designed interface allows medical personnel to view the list of monitoring performed on a specific patient according to the range of selected dates. In addition, when the staff clicks on an item on the list, they access the monitoring details.

4.4.2. Design of the Patient Progress Report Interface

The modeling of the interface "Patient progress report" is shown, which is part of the development of the TA33, according to the description and observation of the UH12.

The interface allows medical personnel to generate, according to the selected dates, a list of the care a given patient received at the health center. Likewise, when the staff clicks on an item on the list, they access the service's details.

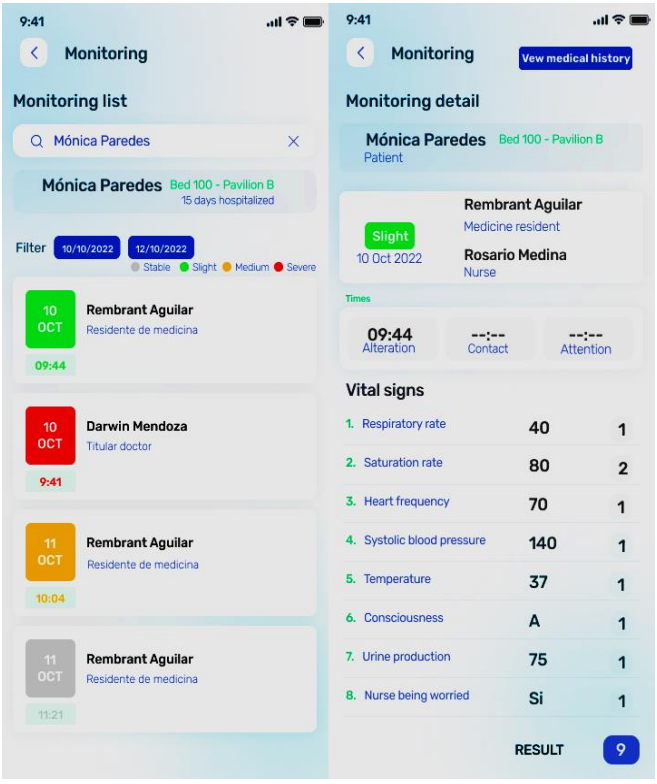

Fig. 15 Monitoring list interface

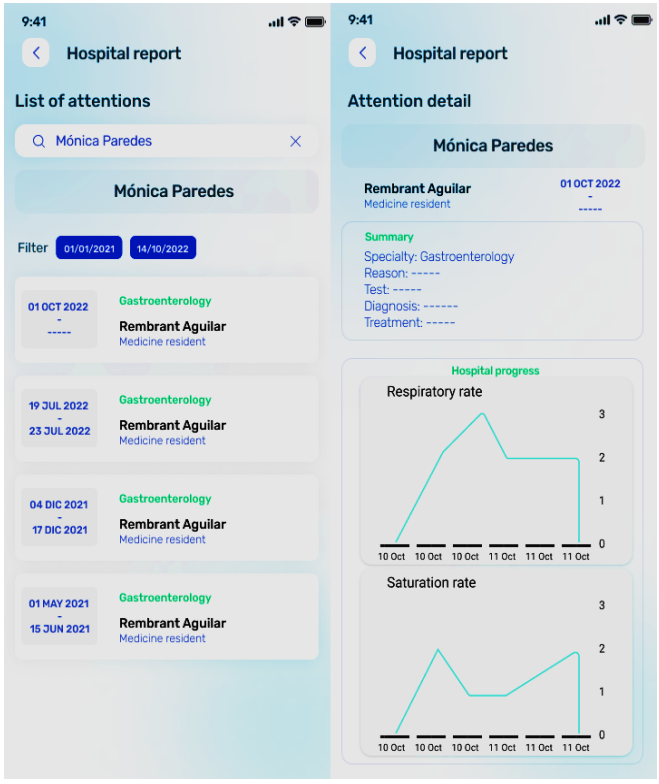

Fig. 16 Patient progress report interface

4.4.3. Design of the User Profile Interface

The following figure shows the modeling of the "User Profile" interface that is part of the development of TA35, according to the description and observation of UH03. In the interface, medical personnel can view their personal data registered in the system. In addition, the interface allows updating of data.

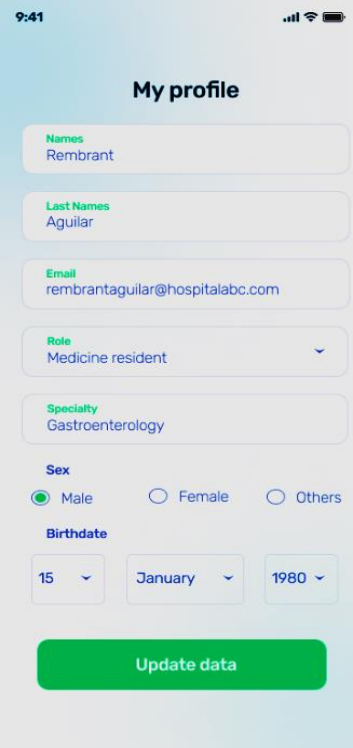

Fig. 17 User profile interface

4.4.4. Retrospect

Table 28. Sprint 3 retrospect

What went well in the interaction? (successes)	What did not go well in the interaction? (errors)	What could be improved in the next interaction? (recommendation for continuous improvement)
Compliance was obtained in developing the interfaces in Figma for the user stories UH11, UH12 and UH03. In addition, the correct distribution of the elements displayed on the screen is emphasized.	It became evident that the report's detail prepared for UH12 had a search filter, which would lead to obtaining more than one result. Therefore, the filter was kept only in a list of attention, where a single result is generated as detail after selecting attention.	An in-depth analysis of the information retrieved on the screen is considered.

4.5. Validation Survey

The design elaborated in the project is evaluated by means of a validation survey. The results obtained from a total of 36 processed cases are summarized in Figure 18, and 12 numbers of elements show a reliability coefficient of 0.892 in Cronbach's alpha, which is displayed in Figure 19.

Case Processing Summary

		N	%
Cases	Valid	36	100.0
	Excluded[a]	0	.0
	Total	36	100.0

a. Elimination by list is based on all variables in the procedure

Fig. 18 Summary of cases

Reliability Coefficient

Cronbach's alpha	Number of elements
.892	12

Fig. 19 Reliability results

This coefficient value is located in the interval [0.8; 0.9[, called "Good" within the reliability assessment, as shown in the following table. Therefore, it is evident that the survey results validate as "Good" the design elaborated in the project.

Table 29. Cronbach's alpha

Interval of Cronbach's alpha coefficient	Reliability assessment
[0 ; 0.5]	Unacceptable
[0.5 ; 0.6]	Poor
[0.6 ; 0.7]	Weak
[0.7 ; 0.8]	Acceptable
[0.8 ; 0.9]	Good
[0.9 ; 1]	Excellent

4.6. Discussions

De According to the importance of monitoring vital signs, highlighted by [4], since it allows the monitoring of the parameters measured by the patient by medical personnel, including respiratory frequency, saturation frequency, heart rate, systolic pressure, temperature, consciousness and urine output. In addition, [24] highlights the existence of the MEWS. This algorithm quickly and easily calculates multiple variables, jointly using the state of consciousness and vital parameters to identify the complete state of health of the patient.

For this reason, it was decided in the investigation to have the design of a module that has the parameters

previously exposed in favor of carrying out correct monitoring. For this, the personnel in charge of monitoring the patient must record the measurements of the vital signs in the system. Based on this, according to the range to which each measurement entered belongs, a score is given, and medical personnel are notified by telephone.

Likewise, another outstanding concept during the literature review is the alert system, of which the authors [5] and [10] highlight that the use of early warning tools favors the actions of medical personnel in reducing the time in the medication change. However, in the present investigation, the improvement of the time regarding the care provided to the patient is covered, for which the sending of notifications before the alteration of the patient's health is included.

During the review of other investigations, the authors [3] believe that the use of mobile phones is not adequate to establish communication in a moment of urgency since it is not feasible to call more than one person; however, the design takes into account the opinions of the authors to improve and establish an effective communication plan by directly contacting the suggested personnel for patient care and providing them with the necessary information from the monitoring that was carried out, in order to improve decision-making regarding the health of the patient.

For which the module's design was thought to correctly exercise the communication between the personnel that performs the monitoring and medical personnel suggested for attention, for which joint work is needed. In favor of this, the authors [25] highlight the importance of teamwork in emergencies to achieve the shortest possible care.

The SCRUM methodology was used because there are several works with good results, see [26-28]

5. Conclusion

After the development of the design of a Monitoring System for Hospitalized Patients (MPH) based on the Modified Early Warning Score system (MEWS), under the use of the Scrum methodology and through the information provided by the participants of a validated survey Using Cronbach's alpha, it was possible to record the optimization of the response time of medical personnel in the care of hospitalized patients based on the design carried out. Likewise, it is concluded in particular that:

- Through an interview with staff from the health area prior to the development of the sprints, it was possible to obtain and analyze the necessary requirements for the construction of the design of the monitoring system in the optimization of the response time of the personnel medical.

- From the development of the interface called monitoring result in the system design, the identification of the values of vital signs measured in hospitalized patients in the MEWS system was achieved.

- Based on the development of the interfaces, the establishment of the patient's clinical history was achieved. In addition, the transfer of information and the case referral to the appropriate medical personnel for patient care is based on the use of notifications and calls to the mobile phone.

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