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## Design of a Booking Management System, with Responsive Design Web Appointments, to Reduce Time and Improve the Quality of Health Care Services



**Abstract:** - Technology is playing an important role, especially in the current need for technological solutions focused on the health sector. There is currently much room for improvement, for example: reducing the long waiting time for patients to book an appointment according to availability in the specialty and doctor. However, there are still health centers that lack technological solutions focused on this, because most of the population does not yet have the knowledge of technology. Given this, and taking into account the needs of users with low knowledge of ICT and contribute to the health sector, will be launched the design and development of a specialized responsive website for the management of medical appointments that will solve in part the order and time of attention of each appointment requested, whose purpose is to improve the quality of care of public health services.

**Keywords:** Technology; interaction; cloud; appointment booking; users; flowchart; responsive.

### I. INTRODUCTION

Today, all public health centers still register their patients' appointments on a first-come, first-served basis or via telephone calls. With technological development and advancement, this process has been adapting to change in an acceptable manner. But there is also the traditional system that is used today in all public hospitals. Likewise, there is still the traditional model of appointment booking that is managed by telephone, which is only provided in 1st level establishments and some 2nd level hospitals in certain specialties. The traditional system of appointment booking is still in place in all public hospitals, but it is not the same as the traditional system [1].

Very often some inconveniences are reported such as loss of medical appointment records, which generates a delay when the patient goes to the health center at the scheduled time, or in another case the doctor does not find in the system his reservation record where the patient is attended as additional after attending all scheduled patients. In addition, the health center gives the patient a voucher of the printed appointment reservation, but sometimes these have been digitally edited, so it is not considered 100% reliable. Thus, this failure is generated in the system causing confusion and difficulty for patients [2]. Most of the activities that are performed in appointment management are managed by the actor who will always be involved in one or more appointments. For example: when a user cancels an appointment, the administrator himself creates the measurement schedules, when a work shift is established, or an employee starts an appointment.

In the field of sustainable public health development, scholars are increasingly concerned and focused on how to ensure that patients can quickly obtain high-quality health services in the context of the overall increase in medical expenses [3].

Despite the benefits of the use of new technologies, most patients still registered using the usual method of orderly queuing, suggesting that health centers and health care providers should promote and encourage the use of the technology [4]. These findings provided useful information in the ideation and construction of the proposed system as it exposes important variables to consider, such as encouraging the use of the system and the important role of physicians in the process of implementing the online appointment booking system.

One of the possible causes of this situation is that not all clinics currently have an online appointment management process. Most public health facilities still register patients on a first-come, first-served basis or via phone calls. The unnecessary effort of going to the clinic hours in advance could be avoided by having a registry that directly sends

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requests to the system for appointments and updates the doctors' schedules. The need for an online appointment management process is not always possible [5].

There are now many hospitals that already have their own web application for patients to book appointments. This will be useful only for a particular hospital. Therefore, doctors who are available at the particular hospital can be seen by the patient and others not. There is no possibility of information about other hospitals or doctors. It is important to connect all doctors and hospitals. So that the search is easy and the patient can easily identify the experts in the area. Another important issue is to get approval from all hospitals and doctors. Hospitals and doctors cannot easily connect with each other. If a hospital or a doctor approves it easily, they may be slow to accept the proposal we make to them in other hospitals or by other doctors. We have to convince the hospital members and doctors to accept our proposal to implement the common appointment booking web application. Physicians should recommend it to the patient to reduce their waiting time [6-7].

First of all, it highlights the big problem of the patient is the delay of waiting time. People doing high-level business do not have free time to visit the hospital. They need their appointment to be booked earlier so that their busy schedule is not interrupted.

This work is mainly proposed is to design a web application that will be useful to reduce the waiting time of patients in the hospital. The patient can give feedback both from the hospital the hospital and the doctors who have treated him/her. treated him. So it is necessary for the patient to know the doctors in a particular field. By using this web application, people can find a particular doctor of interest [8].

## II. METHODOLOGY

The research was developed using the Action Research Methodology proposed by Susman and Evered (1978) [9], given its adaptation in the context of Software Engineering and Information Systems. In which, the five phases present in the iterative process will be applied:

- a. Diagnostic Phase: For the identification and description of the current situation.
- b. Action Planning Phase: To specify the actions that must be executed to improve the problem.
- c. Action Implementation Phase: At this point the planned actions will be implemented. Users collaborate by generating changes that improve the current situation.
- d. Evaluation Phase: Finally, to finalize the actions, the users who initially interact with the system will evaluate the outputs, using appropriate techniques that provide evidence of the quality of the actions undertaken.
- e. Learning Specification Phase: In this phase, the results of the evaluation phase are reflected upon.

All this, oriented to the Azure cloud for availability in the design, development, testing, implementation and hosting our web application, which will allow us to have a robust, flexible and elastic platform. Thus patients will be informed in real time and see the availability of appointments of the day, to request a new appointment online. In this way, it will be a useful tool for the health center and at the same time will solve the problems identified in the research.

### A. Data analysis

It is essential to perform the data analysis process, in order to obtain full understanding and have a complete view of the requirement of the proposed system. For the analysis, INEI data has been collected to know the delay and the average appointment scheduling time for health care in all public establishments in Peru, due to the great demand in the public health sector. In Peru, 43% of the population has SIS insurance, 26% have ESSALUD and 25% have no insurance at all [10]. The latter are attended in public health centers, which generate the greatest demand for medical care and for this reason take more time, generating many queues to make an appointment. Similarly, in the facilities of the Ministry of Health (MINSA), the average time is 12 days, in SALUD it is 19 days, in the Armed Forces and Police it is 21 days, and in clinics it is 8 days. On the other hand, 90.4% of those who obtained a scheduled appointment for the day were processed at clinics, 73.4% at the Ministry of Health (MINSA) and 45.4% at the Peruvian Social Health Insurance (EsSALUD) [11].

*B. Flow Diagram*

In order for the proposed project to be feasible and capable of identifying available actions, a flowchart has been designed, so that the appointment booking system will go through different processes, each time a certain action is initiated, until it finally reaches a specific end state where it can no longer be changed. A flowchart describing the processes to be followed is shown in Figure 1.

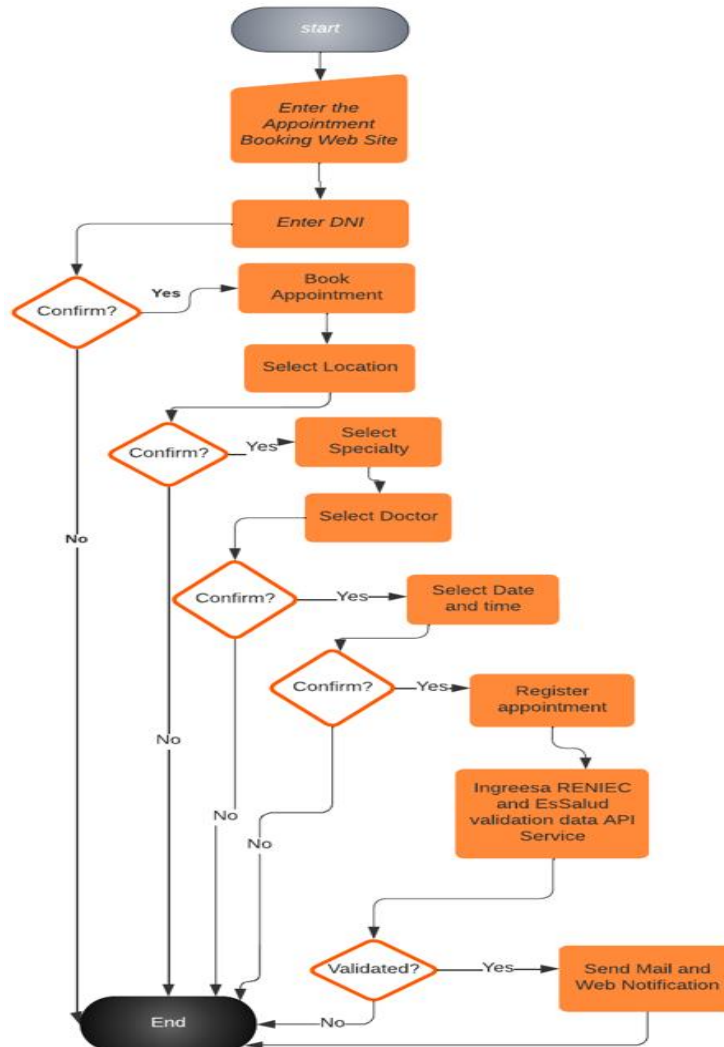


Figure 1. Appointment Reservation Flow Diagram

*Appointment Reservation Authentication Process:* This first form starts with the entry screen of the citizen's DNI. This process allows the user to authenticate through the API-REST of Consulta RENIEC to personalize the attention and continue with the Reservation process. The web application will use only the DNI as an identifier.

*Search Process:* In this process allow you to select the location of the nearest health center, the specialty where you want to be attended, select the specialty of interest, the appropriate physician and the available date and time, and then continue the registration of the Appointment.

*Appointment Registration Process:* In this process the user must enter data of the DNI which will be validated by the API service of RENIEC and EsSalud, in order to be sure that the citizen exists and says who he/she claims to be and not to incur in identity theft. Finally, the appointment will be successfully registered. Then, you can receive a notification of your appointment, which will be sent to your cell phone and via mail, for the user's follow-up. This is the end of the process.

C. *Functionalities of the proposed system*

To achieve the objective of this research, it is necessary to understand the information obtained in the data analysis and flowchart, for the design of the proposed system.

**Web application system:** This web application will be useful for patients to search for a doctor according to their location where they are, where we can know the specifications of the doctor and the hospital. The patient can book the appointment in any hospital by specifying the date, when they need to consult the doctor. In case the appointments are already booked, the available hospitals and doctors are displayed, where the user can select another doctor or schedule his appointment for another date. Users have a unique user ID where patient details are stored. The prescription given by a physician can be stored as a reference. Users have options to rate the doctor and give feedback on their treatment.

**Search for local hospitals:** This web application can access the user's location when the user turns on the global positioning system (GPS) on his/her Android device. The user can search for the hospital that is near him/her in case of any emergency by allowing the web application to access his/her location. Patients can avoid traveling long distances to consult a doctor, instead, they can search for nearby famous doctors and hospitals to schedule their appointment. This also provides time and money consumption to the patient.

**Data collection:** Data such as the location of each hospital, the doctors who are available at a particular hospital, the specialization of the doctors, the availability of a particular doctor at various hospitals, the appointment time for patients at each hospital and the total number of appointments given per day at any particular hospital should be collected for our web application. The patient's opinion about the doctor after each visit is stored in the database, along with the login and prescription information given by the doctor. Then, information about health care awareness camps is intimated to the user by this web application.

**References of Attentions:** After every finalized appointment, patients will receive a short survey by text message, mail and web booking system, to leave their references of the care and booking management. Based on patients' opinions and ratings, where the new patient can get an idea of their future care from a doctor. The patient's report will be saved in his record, which will be useful for the health center.

D. *Use case diagram*

The general use case diagram explained by modeling the functionality of the proposed system and how the user will access the different functionalities of the web system. Figure 2 shows the general use case diagram of the proposed system.

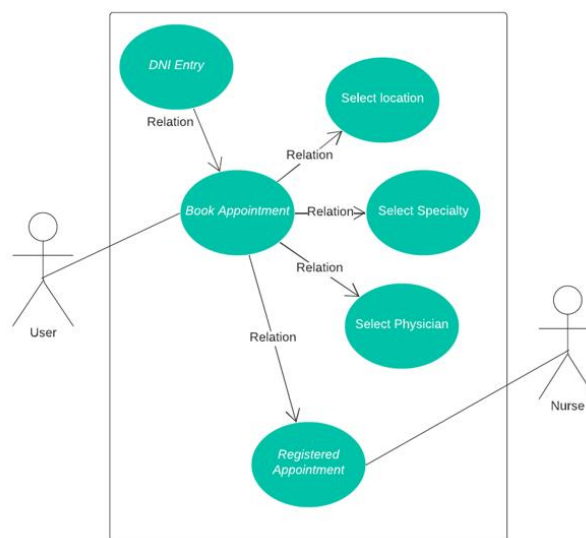


Figure 2. Use Case Diagram

### E. *Benefits of the proposed system*

The application to be developed will have a user interface designed in a simple way so that the user can use the web application efficiently. The administrator has an independent interface to check the information about the availability of the doctors and also about the record of the available doctors and the appropriate time of care for the patient. The system will update all the information automatically about the health center in real time [12].

### F. *Technologies Involved*

*Cloud computing:* The cloud offers a new technology in different multidisciplinary fields that allows to arrange the services of the IT area through the internet. Cloud computing offers different virtual services as the traditional IT department, such as general storage, stream server and database server. The cloud offers a cost-effective model through pay-per-use that allows users or business customers to implement a cloud-based service with minimal investment [12].

*Azure PaaS-based architecture:* The Windows Azure platform [13] is Microsoft's PaaS (Platform as a Service) public cloud. Users or customers create applications on top of the Azure platform, by using programming languages (e.g., c#) and tools (e.g., Visual Studio and SQL server) compatible with Azure. As a PaaS cloud provider, Microsoft is responsible for OS (Operating System) and network compilations and maintenance [14].

*System Framework:* This project presents an appointment management system based on ASP.NET MVC framework. Compared with traditional web development framework, the MVC (Model View-Controller) framework separates the view layer and business logic layer, which allows users to change the view layer code without recompiling the model and controller code, thus increasing code reusability and applicability [16]. The Model-View Controller (MVC) architectural pattern separates an application into three main components: the model, the view, and the controller. Hereafter in this paper, we will call the ASP.NET MVC framework as MVC framework [17]. In this paper, we have proposed a three-tier architecture, where we will implement a responsive web-based appointment booking system to demonstrate its availability [18].

*Google Maps API:* The API that allows us the real-time location of Google Maps, is a technology provided by Google based on AJAX, map-based services. The software uses the public and free Google Maps API service. The system will use a knowledge base formed by tracking user actions. The term originated in 2000 by Roy Fielding, the father of the HTTP specification, and has become widely used by the development community [19].

*API Service:* Through this modality the user accesses our information through an established dedicated line. For this, it is necessary that the user has a server and performs a development using the available API services. The access to this service previously requires the subscription of an Information Supply Agreement. The information will be provided through a point-to-point link (Dedicated Line), using Queue Manager technologies - MQ [20]. This service allows for identity verification and provides security in the performance of various transactions, significantly reducing impersonation attempts.

### G. *Tools to be used*

*Postman:* It is an integrated development environment (IDE) for Windows operating systems. It supports multiple programming languages, such as C++, C#, Visual Basic .NET, Java, Python, Ruby and PHP, as well as web development environments, such as ASP.NET MVC, Django, etc.

*API Service RENIEC and EsSalud:* Composed of different tools and utilities for the entities, which will allow us to create requests to APIs, previously elaborating tests to validate the behavior of RENIEC APIs, which will allow us the possibility of creating query work environments (with global and local variables).

*Microsoft SQL Server:* It is a database management system of the relational model, developed by Microsoft, used by command line or through the graphical interface of Management Studio is Transact-SQL (TSQL), an implementation of the ANSI standard SQL language, used to manipulate and retrieve data (DML), create tables and define relationships between them (DDL).

*AngularJS9*: It is an open-source JavaScript framework, maintained by Google, used for Front End Web development, which will allow you to create and maintain SPA Single Page Application applications. It can implement the MVC (Model, View, Controller) or MVVM (Model, View, View-Model) pattern and allows to extend the HTML vocabulary. The environment is very expressive, readable and fast to develop.

Google Analytics: It is a web analytics tool of the Google company launched on November 14, 2005. It provides aggregated information on traffic arriving to websites according to audience, acquisition, behavior and conversions that take place on the website.

### III. RESULTS

#### A. Functional Module (Prototypes)

In order to provide and meet the needs of users. The following prototypes are designed in a simple way so that the user can use the web application efficiently and according to the current need, the management of medical appointment booking. The web system consists mainly of 3 modules, first to customize the attention, the second for booking the appointment and the third will validate the ID of the citizen for registration as a patient.

1) The booking appointment module: Personalize attention through the RENIEC query where the citizen's Name and Surname data will be obtained to continue with the appointment management and finish with the validation of the person who he/she claims to be. Next, see figure 3.

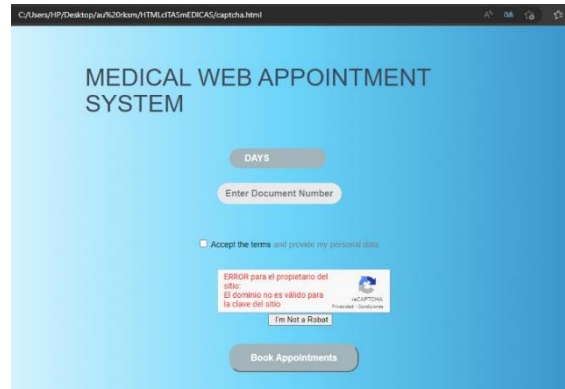


Figure 3. Appointment Reservation

2) The new reservation module: Locate the place where the patient will be seen through Google GPS, select specialty, select doctor, select date and time, additionally you can add a cell phone for confirmation and notification of the reservation. Finally, the user finishes by requesting the appointment. Figure 4 is shown below.



Figure 4. New Appointment Reservation

3) Information validation module: This module allows the management of citizen user information or if the patient is already registered as such or to register him/her as a new one if necessary. The information validation module is important for users to modify their data and be aware of the process of their scheduled appointment. It is

convenient that in each appointment registration the patient's data is validated with their ID to validate if they are a Peruvian citizen, where the name and surname will be automatically filled in the registration fields. The prototype of the Login is shown in Figure 5 below.



Figure 5. Patient validation form

4) Appointment confirmation: Finally, the patient will receive an appointment confirmation email with the booking data such as date and time, which will be validated by the healthcare staff at the hospital on the day of the scheduled appointment, as shown in Figure 6.

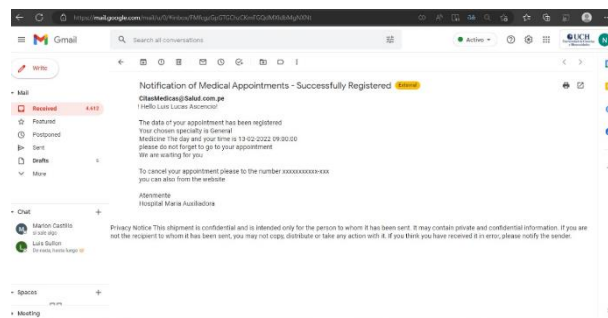


Figure 6. Appointment confirmation by web, e-mail and mobile phone

### B. Survey

At this point we present the analysis and interpretation of the results obtained after carrying out the research process mentioned in the previous chapter.

The final participants were ordinary citizens from different sectors - a sufficient number to carry out the analysis and results of our proposed approach, as mentioned above. Our project aims to conduct an exploratory analysis of the needs expressed in the interviews, obtain data through closed-ended interviews by means of a range of questions and response options, as well as including different sectors and more varied.

By analyzing the needs of the participants or second language learners, individual needs are discovered and not only general ones from the point of view of the institutional participants that bring additional value to the research [21]. For this purpose, the second data collection instrument named above was used: the questionnaire. This tool was chosen because it provides us with direct and easy to assess data; it is easy to carry out; it allows direct comparison of groups and individuals and facilitates feedback on attitudes and adequacy of resources [22]. Interviews and questionnaires are considered to be complementary research tools as they provide different data [23].

For this purpose, as a first phase, the invitation to participate in the interviews was sent by cell phone to the university sector, colleagues, friends and relatives, so that they themselves could distribute them to volunteers in their own environment. Figure 7 below shows the design of the survey questionnaire.

Figure 7. Design of the survey questionnaire

C. *Analysis quantitative*

The results are shown in the following tables in which we identify the questions and their respective results.

a) *Dimension 1:* 76% of the respondents indicated that they would like to agree to the online booking of appointments. On the other hand, 10% of respondents indicate no, because they would like to continue face-to-face. On the other hand, 15% are not sure. Table I of the results is shown below.

TABLE I. Result of Survey one

INDICATOR	OPTIONS ANSWER	CANT.	%
Would you like your medical appointment booking to be managed online (PC or Mobile)?	yes	87	76%
	Not	11	10%
	I am not sure	17	15%
Total		115	100%



b) Dimension 2: 78% of the people surveyed indicated that they would agree that the appointment reservation process should be carried out only with the citizen's ID card. On the other hand, 6% of respondents said no, because they are not sure. On the other hand, 16% are not sure. The following table II shows the results.

TABLE II. Result of Survey two

INDICATOR	OPTIONS ANSWER	CANT.	%
Would you agree that the online management should be only with ID card?	Si	90	78%
	No	7	6%
	I am not sure	18	16%
Total		115	100

c) Dimension 3: 77% of people would like to be able to choose the location of the nearest health center online, while 10% do not because they want to continue to be served at the same location. On the other hand, 12% are not sure. Table III below shows the results.

TABLE III. Survey result three

INDICATOR	OPTIONS ANSWER	CANT.	%
Would you agree to have the option to choose a location to be served online?	Si	89	77%
	No	12	10%
	I am not sure	14	12%
Total		115	100%

d) Dimension 4: Eighty-nine percent of respondents indicate that they would agree to have the option of choosing a physician by specialty based on preference, while 5% of respondents indicate that they would not. On the other hand, 6% are not sure. The following table IV shows the results.

TABLE IV. Survey result four

INDICATOR	OPTIONS ANSWER	CANT.	%
Would you agree to have the option to choose the physician by specialty online?	Si	102	89%
	No	6	5%
	I am not sure	7	6%

Total	115	100%
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e) Dimension 5: 89% of the people surveyed would agree that the appointment booking system should ask for their personal information. On the other hand, 20% of the respondents would not agree to provide information to the appointment booking system. On the other hand, 5% are not sure. Table V below shows the results.

TABLE V. Survey result five

INDICATOR	OPTIONS ANSWER	CANT.	%
Would you like to be reminded of your scheduled appointment by mail or mobile?	Si	75	65%
	No	40	35%
	I am not sure	0	0%
Total		115	100%

D. Results of the five proposed questions

Although in general the number of respondents has been low, most of them were attended in a public hospital previously requesting an appointment in person. Considering that most of them agree with the implementation and management of online appointment booking. Next, Fig. 8 shows the statistical graph of the result obtained in the survey of the 115 citizens. It was concluded that 77% were positive, 13% answered no and 10% were unsure of the questions.

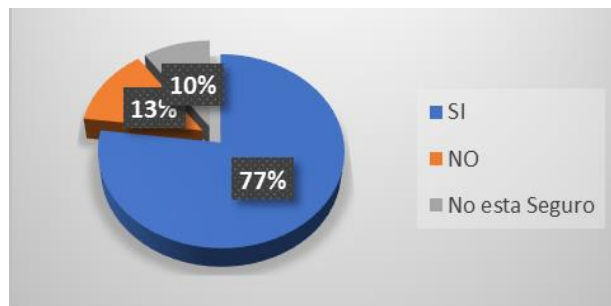


Figure 8. Results of the survey on the proposal to be implemented

*General Argument:* Thanks to the survey, it was determined that 77% of the citizens surveyed consider that the proposed system would improve the management of appointments at the health center and that they would all be willing to use the platform to reduce time and improve the quality of care. In summary, these results indicate that the future project will have a great acceptance and that it generates many benefits for the citizens.

*Efficiency:* Great benefits were obtained with the average respondents, where we are motivated in the implementation of the responsive web system for online appointment booking, due to factors such as: availability, ease of use, nice and understandable design and saving time and transportation.

IV. DISCUSSIONS

The project we will implement will be hosted in the Microsoft Azure cloud that meets high availability and fault tolerance, this will allow us to be superior to others and differentiate ourselves with traditional web systems. The online medical appointments system of the Hipolito Unanue hospital, appointments booked online have a confirmation by email, for the attention of the services for free [24]. Given the existence of similar systems we will

implement notices or reminders to the cell phone and email, with which the user will have a proof to access their scheduled appointment. In addition, there are different projects implemented in the cloud, which allows us to unify different clinics in the sector and provide their services, for easy access and availability [25]. Given the demand for new IT solutions, we will implement a new access design, which will be only with ID card and validation of citizen information and hospital search by GPS, for its location. The proposed system will not only reduce time and operating costs but will also be friendly to different types of users with basic and advanced knowledge [26]. The same, which will be very important for the health sector and patients. However, there are still small details regarding the medical history and physician scheduling process that have not yet been designed in this research because we focus purely on appointment booking, which should be taken into account in case of future implementation to further differentiate ourselves from other systems in the health sector.

## V. CONCLUSIONS

After the research project is implemented, the following conclusions will be obtained based on our methodology development: The system will be easy to use by users in general. Delays in selected processes will be eliminated, patient satisfaction will increase and patient loyalty will be strengthened. Thus, the online appointment system will demonstrate that the use of technology to automate the appointment process will significantly improve time and quality of care. To increase scalability improvements, some experiments can be conducted to receive user feedback on the physician's care. In the future, we intend to implement an option to rate the doctor who attends the appointment once it changes from status to completed, so that users have a reference of the doctor and know how he/she is rated from 1 to 5, with 1 being very bad and 5 being excellent. All this will motivate patients to consult and book new appointments from the web system, and for doctors to strive even harder to improve their care. We conclude that by applying new development tools, it is possible to obtain better benefits in the automation of processes, whose purpose is to improve the quality of care in the health service.

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