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Artículos Científicos

MAS: SISTEMA DE ATENCIÓN MÉDICA. Beneficios para estudiantes de la materia Ingeniería de Software y la comunidad con una aplicación móvil de servicios médicos

MAS: Medical Attention System. Benefits for students of Software engineering's matter and the Community with the Development of a Mobile Application of Medical Services

MAIS: SISTEMA DE ASSISTÊNCIA MÉDICA. Benefícios para alunos da disciplina Engenharia de Software e comunidade com aplicativo mobile de atendimento médico

Mario Martínez García

Universidad de Guadalajara, México

mmgmagma@hotmail.com

<https://orcid.org/0000-0002-5816-8434>

José Roberto Muñoz Reyes

Universidad de Guadalajara, México

Robertomrr1@hotmail.com

<https://orcid.org/0000-0001-6276-9235>

Ricardo Pérez Zúñiga*

Universidad de Guadalajara, México

perezuniga@udgvirtual.udg.mx

<https://orcid.org/0000-0001-9377-6083>

Silvia Ramos Cabral

Universidad de Guadalajara, México

Chivia06@hotmail.com

<https://orcid.org/0000-0003-4204-1700>



*Autor de correspondencia: Ricardo Pérez Zúñiga

Resumen

En el presente trabajo se presenta el desarrollo de una aplicación denominada *sistema de atención médica*, la cual fue creada para procurar reducir el tiempo de atención, costos y traslado del paciente desde su hogar o lugar de trabajo. En tal sentido, el presente artículo muestra el diseño de dicha aplicación para los sistemas operativos Android e iOS. La aplicación tiene un directorio telefónico con números de emergencia, laboratorios e instituciones de salud. Usando la geolocalización, se muestra a los usuarios cuáles médicos se encuentran cerca de su ubicación, en un radio de cinco kilómetros. Asimismo, ofrece un servicio de mensajes asíncronos entre pacientes y médicos. A través de la aplicación, el usuario puede acceder a su receta y descargarla una vez que haya realizado el pago de su consulta.

Para validar la implementación se trabajó con una muestra diagnóstica de 50 participantes, de los cuales 60 % invierte hasta cuatro horas para su atención médica, mientras que 50 % invierte dos salarios mínimos entre la consulta y el traslado. La exploración también demostró que más de 80 % usaría una aplicación móvil para recibir atención médica. En el estudio de usabilidad, ocho preguntas fueron utilizadas con una escala de Liker. Los participantes quedaron satisfechos con la usabilidad de la aplicación, lo que resulta en un conjunto de 85 % con respuestas fácil y muy fácil de utilizar.

El sistema de atención médica se desarrolló para proporcionar a los usuarios nuevas herramientas tecnológicas. Se demostró que esta aplicación reduce significativamente el tiempo dedicado al proceso de atención médica, así como los recursos económicos que se deben invertir en ello.

Palabras clave: aplicaciones móviles, conectividad, consulta médica, Ingeniería de Software.

Abstract

In the present work, the development of an application called "medical attention system" is presented. It was created in order to reduce time on care, costs and patients transfer from their homes or workplace. In this sense, this article shows the application design for Android and iOS operating systems. The application has a telephone directory with emergency numbers, laboratories and health institutions. Using geolocation, users are able to know which doctors are close to their location, within a five kilometers radius. It also offers an asynchronous message service between patients and doctors. Through the application, users can access their prescription and download it once they have paid for their consultation service.

To validate the implementation It was identified in a diagnostic sample of 50 participants. That 60\% invest up to four hours for their medical care between moving of from home and consultation time. We realized that more than 80\% would use an application mobile to receive medical attention, and 50\% of the sample invests, between consultation and transfer, two minimum wages *, besides the spending time that they invest for their care. In the usability study, eight questions were used with a liker scale and the participants were satisfied with the usability of the application, resulting in a set of 85 percent with easy and very easy answers.

The Medical Attention System was developed to provide users with new technological tools. This application significantly reduces time spent and resources, moving of from home or any place else and medical appointments in the care of diseases with basic diagnostic tables and brings patients closer to Doctors for deeper diagnoses.

Keywords: mobile applications, connectivity, medical consultation, software engineering.

Resumo

Neste trabalho é apresentado o desenvolvimento de um aplicativo denominado sistema de atendimento médico, que foi criado para tentar reduzir o tempo de atendimento, custos e transferência do paciente de sua casa ou local de trabalho. Neste sentido, este artigo mostra a concepção da referida aplicação para os sistemas operativos Android e iOS. O aplicativo possui uma lista telefônica com números de emergência, laboratórios e instituições de saúde. Usando geolocalização, os usuários são mostrados quais médicos estão próximos de sua localização, em um raio de cinco quilômetros. Também oferece um serviço de mensagens



asíncronas entre pacientes e médicos. Por meio do aplicativo, o usuário pode acessar a receita e fazer o download após efetuar o pagamento da consulta.

Para validar a implantação, trabalhamos com uma amostra diagnóstica de 50 participantes, dos quais 60% investem até quatro horas no atendimento médico, enquanto 50% investem dois salários mínimos entre a consulta e a transferência. A varredura também mostrou que mais de 80% usariam um aplicativo móvel para receber cuidados médicos. No estudo de usabilidade, foram utilizadas oito questões com uma escala de liker. Os participantes ficaram satisfeitos com a usabilidade do aplicativo, resultando em um conjunto de 85% com respostas fáceis e muito fáceis de usar.

O sistema de saúde foi desenvolvido para fornecer aos usuários novas ferramentas tecnológicas. Esta aplicação tem demonstrado reduzir significativamente o tempo despendido no processo de saúde, bem como os recursos financeiros que devem ser investidos nele.

Palavras-chave: aplicativos móveis, conectividade, consulta médica, Engenharia de software.

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Introduction

Currently, mobile applications represent an opportunity for users because they reduce time, costs, streamline communication and make available services that can improve our standard of living (Álvarez and Fernández, 2020; Brandt et al., 2019; Pérez -Jover, Sala-González, Guilabert and Mira, 2019).

In Mexico, we have the opportunity to contribute to improve our institutions and specifically our health care centers, hence, we must take advantage of technology to help and achieve a first-world health system (Balakrishnan et al., 2019; Gill et al., 2019).

According to data from the App Annie study, in the first quarter of 2018, iOS and Google Play downloads grew more than 10% compared to the first quarter of 2017, and reached 27.5 billion downloads, the highest figure ever. date. In addition, smartphone users (iOS and Google Play combined) consumed 22% more compared to the first quarter of 2017, reaching 18.4 billion dollars, also a record number (Blanco, April 12, 2018).

Google Play downloads, comparing the annual interval between quarters, were especially benefited by markets such as India, Indonesia and Brazil, with the growth of iOS

downloads mainly coming from the US, Russia and Turkey (Blanco, 12 December April 2018).

Every day new developments of mobile applications appear to seek solutions to problems in a specific area, among them we can highlight some developed to provide services in the health field, in psychological, nutrition, dermatological and medical areas (Alessa, Hawley, Hock and de Witte, 2019; Chávez and Pozos, 2016; Pacheco and Krohling, 2020).

Now, a mobile device can be defined as a small device, with the capacity to process information, with permanent or intermittent connection to a network, with limited memory, which has been specifically designed for one function (Baz, Ferreira, Álvarez and García, 2011), while mobile applications are software programs designed to be used on smartphones, tablets and other mobile devices, the purpose of which is to carry out a specific task, often basic, quick and easy to use for the ordinary non-advanced user. (Morillo, 2011).

There are several methods and languages that have different characteristics and limitations in application development (Långkvist, Jendeberg, Thunberg, Loutfi and Lidén, 2018). The development of native applications is based on the software that each operating system provides to programmers, called *Software Development Kit* o *SDK*: Android (Gironés, 2019), iOS (Baz *et al.*, 2011) y Windows Phone (Amaya, 2015; Cuello y Vittone, 2013).

For web applications, its programming language is HTML, JavaScript and CSS, and for the development of this type of applications it is not necessary to use an SDK. The development of hybrid applications is similar to a web application, using HTML, CSS and JavaScript (Ceballos, 2015). Hybrid applications allow us with the same code to obtain the software for different platforms such as Android and iOS (Cuello and Vittone, 2013).

In software environments, an alternative is proposed to optimize the mechanisms of medical care, using technology and bringing medical services closer through information and communication technologies. Any user who has a mobile device and has internet access can use applications that contribute to medical care with quality services. These services seek to reduce attention times, costs and long waits, eliminating the need to travel long distances, bringing users and doctors closer together with synchronous and asynchronous communication (Lunde, Nilsson, Bergland and Bye, 2019; Stevens, van der Sande, Beijer, Gerritsen, and Assendelft, 2019).

According to the World Health Organization (WHO), applications developed to improve health include behavior, well-being and quality of life (Gazdecki, 2016). In fact, according to the report The mobile health global market report 2013-2017: the Commercialization of mHealth apps, 30% of mobile health applications are intended to assist health professionals and 70% for patients (Jahns, 2019).

With the development of this mobile application (Medical Attention System, hereinafter MAS), a platform of specialized services is offered that generates work and medical attention, in the search to reduce attention times, costs and transfers. The application provides services that can be considered as basic diseases (including flu, allergies, muscle aches, among others). In this way, the doctor who attends the patient will have the decision to notify him if he needs to be attended physically or through the application, with which it is intended that users do not waste much time in attending the institutions that provide said services, since that, in general, patients only suffer minor symptoms that can be treated without having to physically present themselves to the scene.

Goals

This application was designed and implemented to allow online medical care when situations were considered first-rate, and has a database to manage the exchange of information. Our hypothesis is that by using this application users will reduce the time and costs in their consultations.

On the other hand, usability was evaluated and we took into account the costs for users in their consultations and the time invested in going to the doctor's office using traditional methods. Finally, the acceptability of an application with these characteristics was consulted with potential users with a sample of 50 participants in the Valles Region, in the state of Jalisco (Mexico).

Development methodology

For the development of this project, the software engineering methodology was divided into four stages. First stage: investigation of existing applications in the market and citizen consultation on the feasibility and viability of an application with the characteristics of the one that was developed. Second stage: gathering of requirements and development of the system. Third stage: implementation. Fourth stage: system tests and results analysis (Sommerville, 2011).

In the first stage, an investigation was carried out on similar applications, of which the following were found:

- Doctoralia: Designed for the management of medical appointments, in addition to allowing you to find specialists from the insurance contracted by patients (Llordachs, 2020).
- American Well: Offers online medical consultations, psychological services and nutritionists. Spruce provides video consultations for dermatological conditions (Schoenberg & Schoenberg, 2020).
- MediQó: Offers consultations through geolocation, where the doctor goes to the patient's home or work area to provide the required care (García and Cervantes, 2020).
- Heal: Provides personalized home consultations for patients requiring a doctor (Dua, Desai y Drobnick, 2020).

Regarding the citizen consultation, a sample was taken and the survey was applied in the Valles Region of the state of Jalisco, in which the contributions shown in tables 1 and 2, and figures 11 and 12, in the evaluation section stand out. of the system tests and results.

The second stage, to collect the requirements that have been defined for the system, was divided into two parts: in the first, existing application requirements were analyzed and opportunities for improvements were identified; in the second, potential clients defined as user-patient and user-doctor were collected; this to improve the experience and interaction of the app in users and doctors (Pressman, 2010).

The methodologies used for the development of the system are model by prototypes (Cuello and Vittone, 2013). This has been selected for the collection of system requirements, system analysis, in addition to the application of the Unified Modeling Language (UML) with the creation of use case diagrams, classes and relationship entity; Another technique

used was the cascade model (Pressman, 2010) for the development of the stages, system design, implementation and tests.

In the third stage, once the structure of the MAS was established and defined, the implementation phase began using PhoneGap for the development of the app, as well as programming languages, such as HTML, CSS, JavaScript, jQuery and PHP, which They allow us to create a native app, optimizing time in code development, since it gives us the power to obtain an application for different Android and iOS operating systems.

In the fourth stage, for the evaluation of tests, a plan was designed to test each element in a functional way; The user access modules, requesting a medical appointment, activated appointments, scheduled appointments, appointment history, configuration, business dictionary, advertising and the functionality of the Google Maps API for Android and iOS were tested with the geolocation of each mobile device . To find out if a test was successful or presented errors, two acceptance criteria were established:

Successful criterion. This phase of the test was considered successful when 99% of use cases were tested; To do this, the relationship between the validated entries, the anomalies found and the expected results was considered.

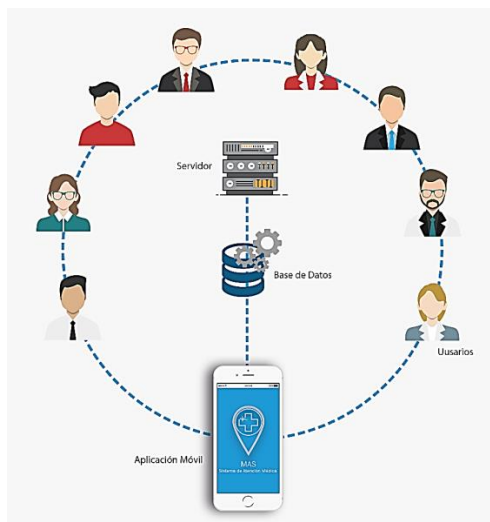
Criterion suspended. In this phase, it was considered that a test should be suspended when there were errors that did not allow the system to continue with the execution of a test process. Therefore, it was considered essential to correct the error before continuing with the following testing processes.

System design and implementation

The MAS project proposes the development of a mobile application for Android and iOS operating systems, with the objective of designing and implementing a mobile application that allows online or personalized medical care in patients with basic-grade diseases through a mobile device.

Figure 1 shows the architecture of the system, which consists of the implementation of a server for sending information from patient users and medical users, as well as being able to generate queries on the database server.

Figura 1. Interfaz de la arquitectura del sistema MAS



Fuente: Elaboración propia

The application of the MAS system allows users-patients, through geolocation, to find doctors available to provide medical care or consultation. Figure 2 shows the login interface and is divided into two parts: the first consists of the flat blue background and the logo established for the system; the second part contains the fields for the user-patient and the user-doctor to enter their username and password in order to be authenticated in the mobile application.

Figura 2. Aplicación MAS (pantalla principal)



Fuente: Elaboración propia

Figure 3 shows the main appearance interface and is divided into two parts: the first shows an advertising banner where you can view business options; the second part shows a menu where the user-patient can request a medical appointment, consult their scheduled appointments, review their care history and update their personal information.

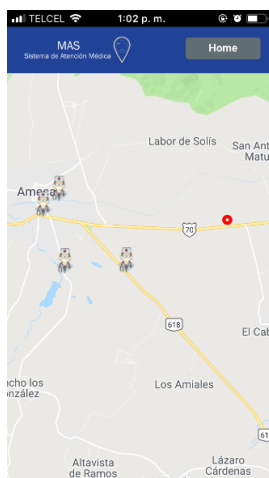
Figura 3. Aplicación MAS (pantalla principal para el usuario-paciente)



Fuente: Elaboración propia

Figure 4 shows the interface for requesting an appointment and has been structured so that the user-patient can identify the doctors closest to their home by means of geolocation. Once the patient selects the closest doctor, he or she can start a conversation of care through a chat to be assessed in the office or directly at home.

Figura 4. Aplicación MAS (pantalla para que el usuario-paciente solicite una cita médica)



Fuente: Elaboración propia

Figure 5 shows the interface for scheduled appointments; The user will be able to consult their scheduled appointments for medical consultations and schedule an appointment with their private doctor or any other doctor in the app.

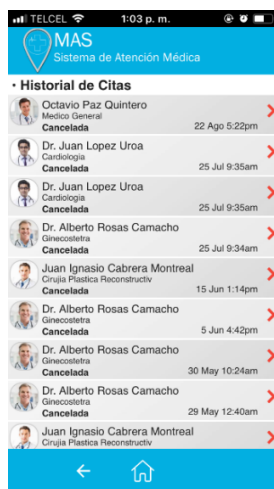
Figura 5. Aplicación MAS (pantalla citas médicas programadas por el usuario-paciente)



Fuente: Elaboración propia

Figure 6 shows the medical appointment history interface; the user will be able to view their history of inquiries made or canceled in real time.

Figura 6. Aplicación MAS (pantalla historial citas médicas del usuario-paciente)



Fuente: Elaboración propia

The user-patient application

This shows the information stored in the server of the database of registered doctors, that is, the search for doctors by patient users through geolocation, which allows viewing available doctors to provide a query in a radius of approximately five kilometers from the location of each user-patient.

The user-doctor application

This allows direct communication between the user-patient and the user-doctor through a chat that is activated once there is a query alert from patient users.

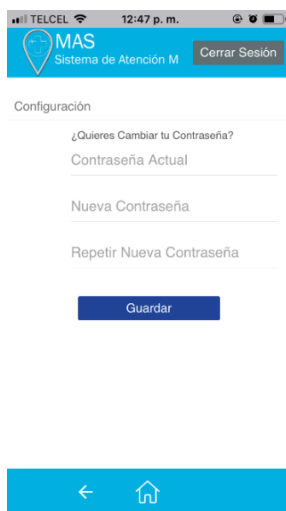
Evaluation of system tests and results

To comply with the verification of the correct operation of the MAS, different types of tests were developed that fulfill each of the functions of the system. For each case of function, a type of test was developed.

Configuration tests

Figure 7 shows the result of the test, where it was validated that users-patients and users-doctors can update their personal information required by the system.

Figura 7. Aplicación MAS (pantalla configuración de contraseña)

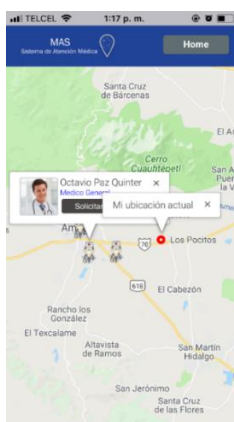


Fuente: Elaboración propia

Geolocation tests

Figure 8 shows the result of the validation test on the location of the user-patient, as well as the visualization of nearby doctors in an area of five kilometers.

Figura 8. Aplicación MAS (pantalla geolocalización)



Fuente: Elaboración propia

In addition to checking the status change of the request medical appointment button (as shown in figure 3), once the user requests an appointment, the button changes to an activated appointment, as shown in figure 9.

Figura 9. Aplicación MAS (pantalla menú cita médica)

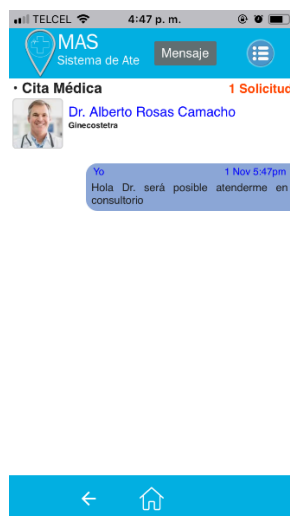


Fuente: Elaboración propia

Integration testing

Figure 10 shows the result of the user-patient interface test, where communication through chat is evidenced when the patient contacts the doctor, as well as the status tests in the request for medical attention.

Figura 10. Aplicación MAS (pantalla chat usuario-paciente)



Fuente: Elaboración propia

Results

When applying the survey to the possible users of the application about their perception of medical care in the Valles Region of the state of Jalisco (Mexico), we found that more than 60% think that the service is bad, as shown in table 1.

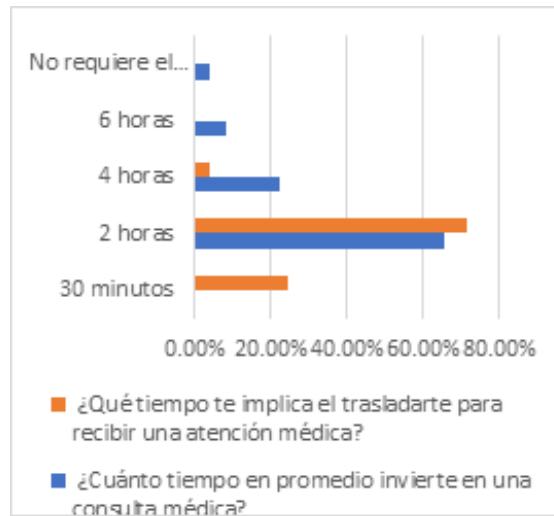
Tabla 1. Percepción de la atención médica

	Buena	Mala
En general, ¿cómo califica a las instituciones que brindan servicios de salud?	32 %	68 %
Considera que el tiempo que hay entre consulta médica es...	38 %	62 %
Considera que la calidad de atención que le brinda el personal de salud es...	44 %	66 %

Fuente: Elaboración propia

Regarding the time of care and transfers that users of the medical service invest for their medical care (basic or first level in the Valles Region of the state of Jalisco, Mexico), we detected that more than 60% of the sample invest up to four hours for their medical care (between travel and consultation time, as shown in figure 11).

Figura 11. Tiempo invertido en la atención médica



Fuente: Elaboración propia

We realize that today and in the XXI century there are more people with mobile devices than with internet in the Valles Region of the State of Jalisco (Mexico), and that more than 80% would use a mobile application to receive medical attention (such as shown in table 2).

Tabla 2. Disponibilidad para utilizar la aplicación MAS

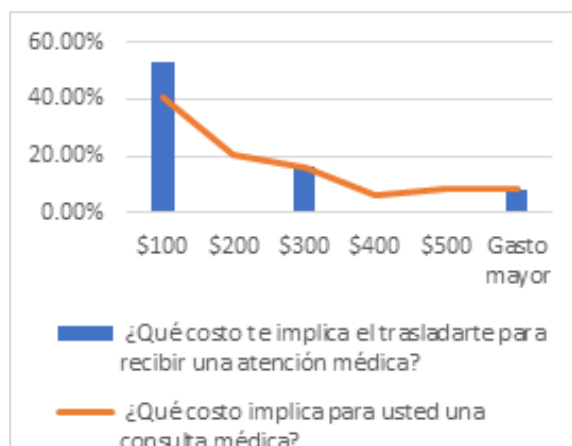
	Sí	No
¿Dispone de un dispositivo móvil inteligente?	96 %	4 %
¿Cuenta usted con acceso a internet?	92 %	8 %
¿Utilizaría una aplicación móvil para recibir una consulta médica especializada desde su teléfono, que cuente con médicos a su alrededor?	64 %	36 %
¿Le gustaría recibir una consulta médica directamente en su domicilio?	100 %	-
¿Utilizaría una aplicación móvil que le ahorre tiempo de traslado para recibir una atención médica?	74 %	26 %
¿Utilizaría una aplicación que le brinde atención médica las 24 horas en línea?	78 %	22 %
¿Utilizaría una aplicación que le brinde atención médica las 24 horas directamente en su domicilio?	86 %	14 %
¿Utilizaría una aplicación móvil que le brinde	90 %	10 %

servicios para solicitar ambulancia?		
¿Utilizaría una aplicación móvil que le brinde servicios de contacto de laboratorio clínico?	92 %	8 %

Fuente: Elaboración propia

On the other hand, 50% of the sample commented that they spend two minimum wages between consultation and transfer, plus the day they must use for their care. This means that they must use two minimum wages, in addition to the wages they earn in one working day, as shown in figure 12.

Figura 12. Recursos invertidos para recibir atención médica



Fuente: Elaboración propia

To register the perception of usability, a survey with eight items was used, using a Likert scale with a range between 1 (very easy) and 5 (very difficult). The survey identifies the perceived usability level from 1% to 100%. Table 3 shows the results obtained from the usability test and the weighting obtained.

Tabla 3. Resultado de usabilidad

PREGUNTA	Muy fácil	Fácil	Normal	Difícil	Muy difícil
1.- Identifíquese en la aplicación, utilizando su usuario.	100	100			
2.- Solicite una cita médica y seleccione el médico que prefiera.		90	10		
3.- Entable una conversación con dicho médico.		70	30		
4.- Agende una cita médica.		80	20		
5.- Consulte sus citas médicas a través de su historial.		80	20		
6.- Cambie la contraseña actual por		100			

una diferente.					
7.- Visite el portal web de alguno de los negocios.		80	10	10	
8.- Realice una llamada desde su directorio de número de emergencias.		90	10		

Fuente: Elaboración propia

Discussion

The health care system significantly reduces the time patients spend on primary or first-level care medical appointments because there is no need to travel and wait to be seen. Asynchronous communication with the doctor is possible with this application. MAS reduces costs for three reasons: a) users do not lose their working hours for medical appointments for basic or first level care, b) they do not spend on transportation and c) the costs of consultations are 50% cheaper than the market average .

The evaluation of the described application and the techniques used could have some limitations due to the low number of participants (50 participants), and your answers are based on your own perception. The privacy policy guarantees honest answers because they were anonymous to ensure that their comments were free and without any abstention.

Mobile health applications are contributing to a model of assisted medicine mediated by technologies, which have come to help in the monitoring and medical care processes to increase efficiency and improve diagnoses and treatments. We are in an era of technological development in which our country cannot be left behind and it is necessary for institutions to promote this type of development that will allow us to keep up with the most developed

countries; otherwise, we will be immersed in foreign technology consumerism (Santamaría y Hernández, 2015).

Comparison with previous works

The functions of the developed application were compared with others that exist in the market. An example is Doctoralia, which offers a database of doctors to schedule an appointment with the closest doctor and according to their specialty. On the other hand, American Well only provides health care services focused on the areas of nutrition and psychology; Furthermore, in this case, doctors can interact with users through video consultations to suggest specialized solutions, while Spruce focuses its attention on users with basic dermatological problems through video consultation.

The application presented in this article was compared with three other applications, which, although practical and functional, have limited services compared to those proposed in MAS (Table 4).

Tabla 4. Tabla comparativa de servicios y características entre Heal, MediQó y la aplicación desarrollada

Características y funciones disponibles en la aplicación.	MediQó	Heal	MAS
Consulta a domicilio.	X	X	X
Información personal del médico.	X	X	X
Información personal del paciente.	X	X	X
Programe una cita y reciba notificación 30 minutos antes.	X		x
Historia clínica del paciente.	X		x
Kit de medicina.	X	X	x
Entrega de medicamentos a domicilio.	X		x
Receta o aplicación escrita.	X	X	x
Servicio de ambulancia.	X		x
Geolocalización.	X	X	x
Chat.	X		x
Videoconsulta.			x
Servicios en línea.	X	X	x
Servicio de recomendación.			x

Fuente: Elaboración propia

Conclusions and future work

This project presents the results of the development of the medical care system built to provide users with new technological tools that facilitate obtaining a medical consultation without the need to invest too much time or resources in the care of simple diseases.

With the use of the MAS application, patients save time and money, since the consultation costs 50 pesos, which reduces more than 75% of the expense invested with traditional methods and without losing the working day.

Therefore, we can conclude that the usability of the MAS system is acceptable when considering the average of 85% in the range of responses 1 and 2 (very easy and easy). Even so, we identify aspects that can be improved such as the following: enable a health history for each user, with levels of glucose, cholesterol, triglycerides, among others, that influence health; incorporate modules to monitor the physical conditions of patients to receive medical advice and suggestions for habits to prevent diseases; and add the history of vaccines that users have received.

Through this application, a user can request a medical appointment using geolocation, which is integrated to show which doctors are close to their location, within a radius of five kilometers. In addition, it allows interaction between a user and a doctor through a chat as a first remote approach. In fact, if the doctor considers it necessary, he will direct the user to go to his office or office for a personalized review. In this study, a doctor will begin to generate the prescription online in case the disease requires it. Once the user has made the payment, they can download their prescription and they can buy the medicine.

Applications with characteristics such as those of the system exposed in this article help to maintain a healthy distance between patients and doctors, reducing large groups of patients who wait in clinics or doctor's offices, which reduces the possibility of infections, as happens with the covid-19.

Developments like this must be analyzed by students in the areas of Software Engineering, Algorithms and those who study in the Educational Programs of Systems, Computing, Electronics, Mechatronics and related masters to motivate them to implement their own innovations and / or improve this proposal.

Likewise, we coincide with publications and research in which it is emphasized that the development of applications aimed at strengthening medical care modify our lives, since they allow doctors to have more inputs to make better diagnoses, while offering patients a better quality of life.

Finally, as future work, the need to incorporate modules to monitor the habits and physical conditions of patients and correlate them with their health to prevent diseases is considered.

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Rol de Contribución	Autor (es)
Conceptualización	Mario Martínez García
Metodología	Ricardo Pérez Zúñiga
Software	José Roberto Muñoz Reyes
Validación	Silvia Ramos Cabral
Análisis Formal	José Roberto Muñoz Reyes
Investigación	Mario Martínez García
Recursos	Mario Martínez García
Curación de datos	José Roberto Muñoz Reyes
Escritura - Preparación del borrador original	Mario Martínez García
Escritura - Revisión y edición	Ricardo Pérez Zúñiga
Visualización	Silvia Ramos Cabral
Supervisión	Mario Martínez García
Administración de Proyectos	José Roberto Muñoz Reyes
Adquisición de fondos	Mario Martínez García