Bulletin of Electrical Engineering and Informatics
Vol. 14, No. 5, October 2025, pp. 4050~4062
ISSN: 2302-9285, DOI: 10.11591/eei.v14i5.9175

Mobile application to optimize appointment management in a specialized dental center

Joel Urbina-Novoa, Michael Cabanillas-Carbonell
Facultad de Ingeniería, Universidad Privada del Norte, Lima, Perú

Article Info

Article history:

Received Aug 19, 2024
Revised Aug 30, 2025
Accepted Sep 11, 2025

Keywords:

Appointment management
Mobile application
Population
Sample
Scrum

ABSTRACT

The objective of the research was to implement a mobile application for the management of appointments in a specialized dental center, to improve patient care, allowing them to make their reservation from the place and at the time they want. The research has a quantitative approach, of experimental type with a pre-experimental design. The population consisted of 70 patients, with a total sample of 60. The SPSS statistical software was used for the elaboration of the results, obtaining positive results. With all the above mentioned in this research work, it is concluded that the implementation of the mobile application for appointment management for the dental center will facilitate patients to have better attention, which allows a reduction of time and satisfaction with the service. In indicator 1, referring to appointment registration time, a reduction of 44.13% was obtained. In indicator 2 on the number of patients presenting for appointments, an increase of 17.58% was obtained, and finally, in indicator 3 on the level of satisfaction, an increase of 65% was obtained.

Corresponding Author:

Michael Cabanillas-Carbonell
Facultad de Ingeniería, Universidad Privada del Norte
Lima, Perú
Email: mcabanillas@ieee.org

1. INTRODUCTION

At present, people demand new technologies that help facilitate their daily lives. Technology has become an indispensable part of our daily lives. In the health sector, human-centered IoT-based monitoring systems are increasingly used to support chronic care and improve patient outcomes [1]. Online appointments have increased thanks to technological advances and the reach of the internet; they require facilities to obtain a medical appointment [2]. The integration of ICT has revolutionized health services, and international frameworks such as Health in All Policies promote intersectoral collaboration to improve equity and service delivery [3]. The current situation underlines the importance of technological innovation in the provision of health services to support good health. However, studies show that adaptation to ICT solutions, especially among older adults, remains a challenge due to usability and accessibility issues [4], [5].

More than 318,000 mobile applications focus on the field of health, and the user adoption is on the rise as these applications are increasingly being downloaded and used by a large segment of the population [6]. Likewise, the number of mobile applications continues to increase, aiming to support users in health management. However, challenges in cybersecurity and data protection remain critical in healthcare IoT systems [7]-[9].

Difficulties in getting a medical appointment on time become a serious problem. Patients wait approximately 18.5 days in US metropolitan areas for an appointment [10]. Health services in developing countries face a similar situation. In the country of China, limited medical resources lead to an imbalance

between the demand for outpatients and the supply of healthcare [11]. The appointment system is the core of patient control, it is the access that permits you to access care. A well-designed appointment system has the potential to increase the utilization of expensive resources and reduce waiting time for patients [12]. Recent studies have shown that appointment-scheduling systems, even in contexts like blood donation, can improve attendance and operational efficiency during health crises such as the COVID-19 pandemic [13].

Given the current emergency healthcare situation, the demand for medical care is increasing, and time management has become a critical factor for both patients and healthcare providers. A hybrid decision-support strategy has been shown to effectively reduce waiting times and improve operational efficiency in clinical environments [14]. One of the most effective ways to improve healthcare efficiency is through online patient appointment systems, which have shown a significant impact on service quality and patient satisfaction [15]. However, lateness is common. Studies have revealed that a major challenge in appointment systems is patient arrival times, as patients often arrive early or late, which causes congestion and wait times [16], another study indicates an average of 17 minutes before the appointment with a standard deviation of 30 minutes [2]. Late arrivals lead to system congestion or provider downtime. The COVID-19 disease pandemic accelerated the development of online healthcare services [17], [18], helping to reduce in-person care appointments, favoring those with difficulties in going to a medical center and those who were far away from being seen online. with specialist doctors allowing them to save their lives [19]. In addition, hybrid algorithms such as particle swarm optimization-support vector machine (PSO-SVM) have been proposed to support COVID-19 screening and decision-making processes, contributing to more efficient healthcare delivery [20]. For this, it is essential to redesign the care model based on the principles of primary health care, which emphasize integrated services, community engagement, and improved problem-solving capacity within health units [21].

The goal of this research is to improve the efficiency and experience of both patients and center staff. The application will optimize and improve appointment management, time, and compliance. For patients, it will allow them to easily book, modify or cancel appointments from their mobile devices, and access their appointment and treatment history. For center staff, it will facilitate agenda management and improve communication with patients, reducing absences and improving personalized care.

2. LITERATURE REVIEW

The appointment booking app aimed to provide enhanced online booking [22]. The additional objective of the system is to provide a single centralized service to patients and users who require it. Provide a single platform to schedule an appointment at any time within the user's geographic region. Likewise, it seeks to eliminate the concept of waiting time in the hospital, making it easier for the user to reserve and cancel the appointment in advance, the ease of online payment. Resulting in a reduction in the time that the patient takes when requesting a medical appointment [23].

A mobile application was implemented which was created to try to reduce attention time and costs, designed the application for Android and iOS operating systems [24]. Offering an asynchronous messaging service between patients and doctors. There was a diagnostic sample of 50 participants, of which 60% invested up to four hours for their medical care, while 50% invested two minimum wages between the consultation and the transfer. The exploration also showed that more than 80% would use a mobile app to receive health care. It was shown that this application significantly reduces the time dedicated to the medical care process, as well as the economic resources that must be invested in it. It was also sought to optimally schedule a certain number of appointments in a certain number of time slots with the use of simulations for the evaluation of schedules and optimization through simulation techniques [25]. Giving a numerical result that significant improvements can be achieved compared to standard programming practice.

Using an intelligent software system in UAE, the objective was to design and implement the system and mobile application "Mwa3edk" for the process of requesting a medical appointment in hospitals and medical clinics [26]. Connecting a large number of hospitals and clinics with users in the United Arab Emirates. Also, users will describe their symptoms and the app will give them recommendations using the built-in artificial intelligence method. Likewise [27], was intended to be able to design an intelligent assistant for the management of medical appointments and records. Making it easier for patients to follow up on appointments and reducing registration time at the clinic, just as it was intended to have a prototype for evaluations of health appointments.

3. METHOD

For the present work, it was decided to use the agile method of Scrum to develop the prototype of the project. Scrum, according to Cano *et al.* [28] is a management framework for the incremental development of products, using one or multifunctional teams. It is managed through a structure of roles, meetings, rules, and artifacts. The teams are in charge of creating and adapting the processes within this framework. Scrum uses fixed-length iterations called Sprints, which take 14 days (2 weeks) or 30 days.

3.1. Scrum roles

According to Timkyw *et al.* [29] indicates that it is a small team of people, which consists of a Scrum Master, a product owner (Product Owner), and developers. It does not have sub-teams or hierarchies, in which they are focused on one objective at a time, the product objective. The Scrum team is cross-functional, which means that the members have all the necessary skills to create value in each Sprint, usually numbering 10 or less.

3.1.1. Scrum Master

The Scrum Master is tasked with implementing Scrum according to its guidelines and ensuring that the Scrum Team operates effectively. Additionally, the Scrum Master plays a key role in facilitating collaboration and continuous improvement within the team, helping to remove obstacles and promote agile best practices. Facilitates the agile process, ensuring that the team follows Scrum principles, eliminating impediments, and helping to optimize the workflow.

3.1.2. Product owner

Responsible for effective project management, as well as for maximizing the resulting value, he is like the owner of the project. Focuses on the product vision, prioritizing the backlog and ensuring that the team develops the features that bring the most value to the business and users.

3.1.3. Developer

Developers are the team members responsible for building various components of a functional increment during each Sprint. They are in charge of the technical construction of the application, implementing the functionalities, correcting errors, and ensuring the quality and efficiency of the code to meet the established requirements.

3.2. Scrum artifacts

According to Schwaber and Sutherland [30] the artifacts are designed to maximize the transparency of the information. Each artifact ensures that it provides information that improves the transparency and focus with which progress can be measured.

3.2.1. Product backlog

The product backlog organizes in a structured manner everything necessary to enhance the final product. It serves as a prioritized list of all features, improvements, and fixes needed for the development of a mobile application. It is managed by the product owner, who prioritizes items according to business value and user needs and can be continuously updated as new requirements arise.

3.2.2. Sprint backlog

It includes the set of product backlog items chosen for the sprint (what), the sprint goal (why), and an actionable plan to deliver the increment (how). This subset of the product backlog contains the specific tasks that the development team commits to completing during the sprint. Managed by the team, it provides a clear and focused direction for short-term efforts, ensuring alignment with sprint objectives and promoting efficient progress. Additionally, it fosters accountability and clarity within the team, helping to track progress and adapt as needed.

3.2.3. Increment

Each increment builds upon all previous ones and undergoes thorough verification to ensure functionality, guaranteeing that all increments are operational. For the increment to deliver value, it must be usable. The key features of mobile applications include high performance and availability, which is why the client-side layer is developed to function offline, as demonstrated in the architecture in Figure 1. This offline capability enhances user experience by ensuring consistent access and reliability even when network connectivity is limited.

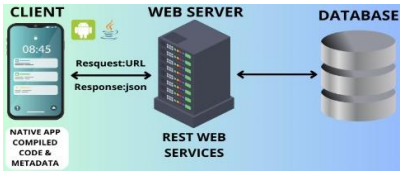


Figure 1. Mobile application architecture

4. SOLUTION DEVELOPMENT

This section outlines the procedure for developing the mobile application prototype, adhering to the lifecycle methodology. Additionally, the next section explains the tools to be utilized in the case development, along with the steps for implementation.

4.1. Hardware

In mobile application development, physical components, such as mobile devices, servers, and networking equipment, are necessary to run, test, and support the application. This ensures the application's performance and compatibility in different environments. Table 1 shows the features of mobile equipment, and Table 2 shows the characteristics of desktop computers.

Table 1. Mobile equipment features

Equipment	Features
Mark/model	Samsung Galaxy A3
Processor	Quad-core 2.5 GHz
RAM	2 GB
Screen size	5.1
Storage	32 GB

Table 2. Desktop computer characteristics

Equipment	Features
HDD	500 GB
Processor	Core i3
RAM	4 GB
Display	21.5”
Operating system	Windows 10 professional 64 bits

4.2. Software

It covers the programs, tools, and operating systems used for both the application's development and operation, such as programming languages, IDEs, database management systems, and libraries. Software defines how the application is built and runs on the hardware. Table 3 shows the programs/tools to be used with their respective descriptions and licenses.

Table 3. Software

Programs/tools	Description	Licenses/free software
Visual studio code	Code editor	Free
Android studio	Development environment	Free
Laragon	Tool to create different development environments	Free
Microsoft office	Office tool	Educational license
DigitalOcean	Virtual server	License
XAMPP	MySQL database management	Free

4.3. Sprint planning

It is a meeting at the beginning of each sprint where the development team, guided by the Scrum Master and the Product Owner, selects the most priority product backlog items to work on during that sprint, defining clear goals and planning how they will be implemented. The work to be done for each Sprint is established. He makes sure attendees are prepared to discuss the most important topics. The Scrum Team may also invite other people to attend sprint planning to provide advice [30].

4.3.1. Impact matrix

There is a priority classification in Table 4 that will be used to classify the functional requirements (FR).

Table 4. Impact matrix

Priority	
Very high	1
High	2
Half	3
Low	4
Very low	5

4.3.2. Prioritized product backlog

Provides an ordered list of features, enhancements, and fixes that should be implemented in a mobile application, organized according to their value and priority for the business. The product owner is responsible for prioritizing these items to maximize the impact on users and project goals, ensuring that the team works on what is most relevant. The product backlog shows the FR (Table 5), properly ordered according to priority; it also includes its requirement, estimated time, and history number.

Table 5. Product backlog

FR	History	Estimated time	Story points	Priority
FR1: the application must have a login so that the user can enter the main menu.	H1	2	20	1
FR2: the application must be able to record user data.	H2	3	20	1
FR3: the application must be able to update the user data.	H3	3	40	1
FR4: the application must be able to register an appointment and show the specialties that the dental center has and the type of appointment that the user requires.	H4	2	40	2
FR5: the application must be able to show the different doctors as well as their schedules for each and select the day of the appointment reservation.	H5	5	80	3
FR6: the application must be able to show a total summary of the appointment record, before being registered and validated by the user.	H6	3	40	3
FR7: the application must be able to show all the registered and pending appointments of the user, with their respective data.	H7	2	20	4

4.3.3. Workplan

In this section, we look at the work plan (Table 6), which is an essential tool that the Scrum Team will use for planning and managing fieldwork because it allows a clear vision of the activities that must be developed to complete each sprint. Figure 2 shows the time it takes the team to develop the points of the user story, to verify in greater detail the degree of progress in the sprint estimates.

Table 6. Distribution per sprint

	FR	History	Estimated time	Story points	Priority
Sprint 1	FR1: the application must have a login so that the user can enter the main menu.	H1	2	20	1
	FR2: the application must be able to record user data.	H2	3	20	1
	FR3: the application must be able to update the user data.	H3	3	40	1
Sprint 2	FR4: the application must be able to register an appointment and show the specialties that the dental center has and the type of appointment that the user requires.	H4	2	40	2
	FR5: the application must be able to show the different doctors as well as their schedules for each and select the day of the appointment reservation.	H5	5	80	3
Sprint 3	FR6: the application must be able to show a total summary of the appointment record, before being registered and validated by the user.	H6	3	40	3
	FR7: the application must be able to show all the registered and pending appointments of the user, with their respective data.	H7	2	20	4

4.4. Development

This process was developed using Balsamiq mockup software for prototyping. It allowed us to generate the following sprints.

4.4.1. Sprint 1

In the first sprint, we focused on working with user stories 1, 2, and 3 of the product backlog:

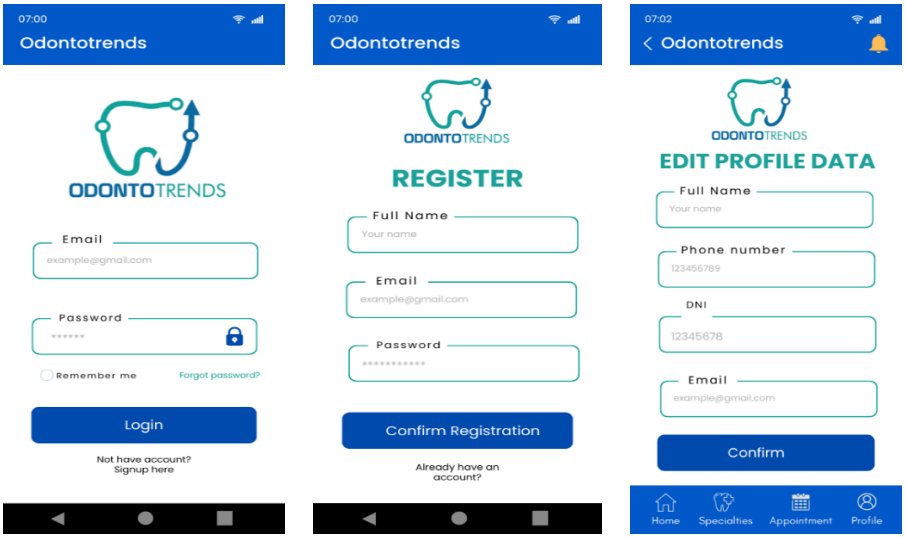
a. FR 1: the application must have a login so that the user can enter the main menu.
b. FR 2: the application must be able to record user data.
c. FR 3: the application must be able to update user data.

During Sprint 1, three key interfaces were developed for the mobile application. Figure 2(a) shows the login screen where users enter their credentials to access the system. Figure 2(b) presents the registration form for new users to create an account. Figure 2(c) illustrates the profile update interface, allowing users to modify their personal information.

4.4.2. Sprint 2

In the second sprint, we focused on working with user stories 4 and 5 of the product backlog:

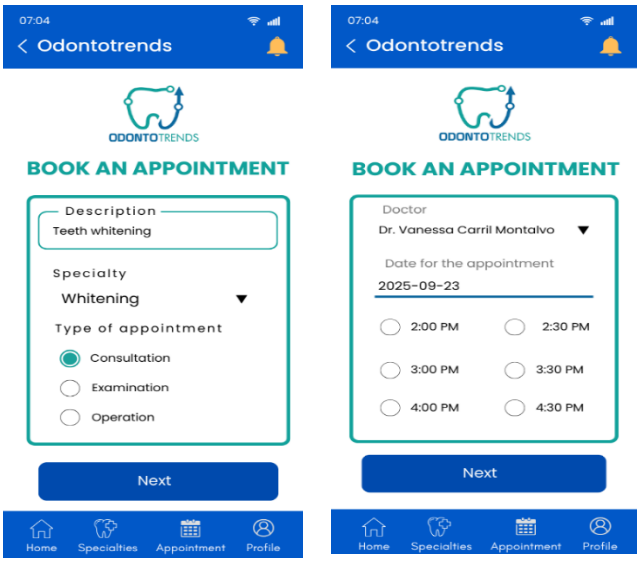
a. FR 4: the application should allow users to register for appointments and show the dental center's specialties and the type of appointment they require.
b. FR 5: the application should be able to display the different physicians and their schedules for each and select the day of the appointment reservation.



(a) (b) (c)

Figure 2. Sprint backlog 1; (a) login interface, (b) registration interface, and (c) profile update interface

During Sprint 2, two interfaces were developed to facilitate appointment booking. Figure 3(a) shows the screen where users can select the dental specialty and type of appointment. Figure 3(b) presents the interface for choosing the date and time of the appointment based on available slots.



(a) (b)

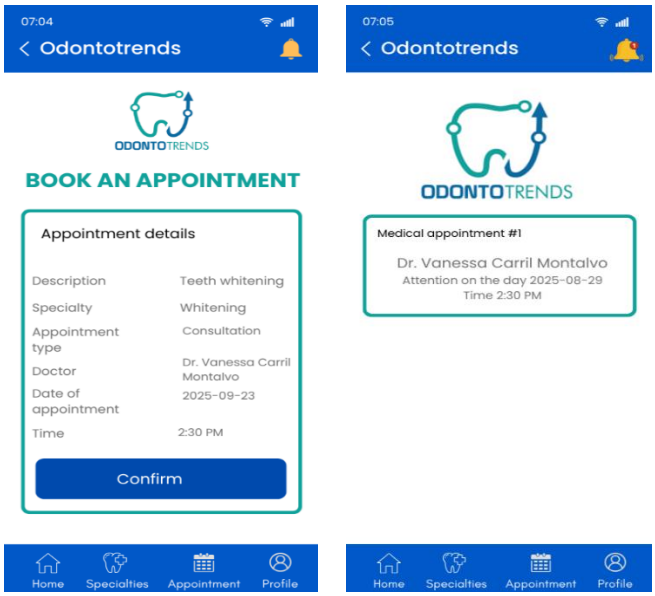
Figure 3. Sprint backlog 2; (a) specialty selection interface and (b) appointment scheduling interface

4.4.3. Sprint 3

In the third sprint, we focused on working with user stories 6 and 7 of the product backlog:

a. FR 6: the application must be able to display a total summary of the appointment record before it is registered and validated by the user.
b. FR 7: the application must be able to display all the user's registered and pending appointments, with their respective data.

During Sprint 3, two final interfaces were created to complete the appointment process. Figure 4(a) displays the summary screen showing all appointment details before confirmation. Figure 4(b) shows the list of registered and pending appointments for the user.



(a) (b)

Figure 4. Sprint backlog 3; (a) appointment summary interface and (b) registered appointments interface

5. RESULTS AND DISCUSSION

5.1. KPI 1: "appointment recording time"

In this section, a descriptive analysis was performed for the "appointment record time" indicator, the comparison between the pre-appointment time and post-appointment time records, as shown in Table 7. Then the histogram was made for the pre and post-times shown in Figure 5.

Table 7. Frequency of the indicator appointment recording time

		Time pre	Time post
N	Valid	60	60
	Lost	0	0
Mean		19.33	10.80
Median		19.00	12.00
Mode		23	12
Desvest		3.057	3.080
Varience		9.345	9.485
Minimum		15	5
Maximum		25	15
Sum		1160	648
Percentile	25	16.25	9.00
	50	19.00	12.00
	75	22.75	13.00

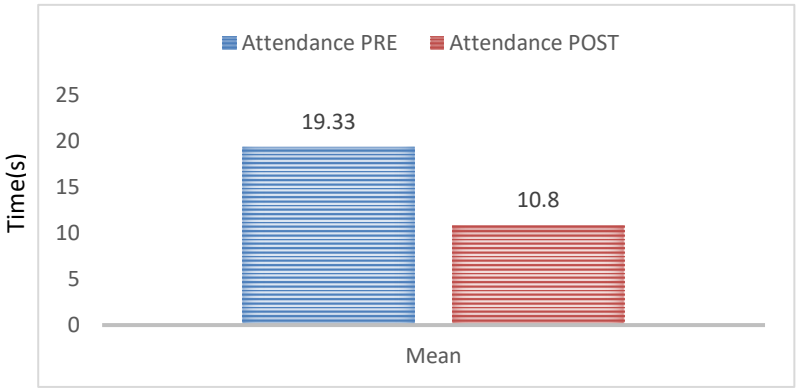


Figure 5. Histogram pretest and posttest of the indicator appointment registration time

According to the results shown in Table 7 and Figure 5, for the indicator level of time with the implementation, the mean value in the pre-test was 19.33, and the mean value in the post-test was 10.8. The results indicate that there was a reduction of 44.13%. Next, the normality test will be carried out as shown in Table 8. Then, the normality test of the Appointment recording time indicator was performed as shown in Figure 6.

Table 8. Test normality of indicator 1

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Stadistic	gl	Sig.	Stadistic	gl	Sig.
Time pre	.161	60	.001	.913	60	.000
Time post	.168	60	.000	.924	60	.001

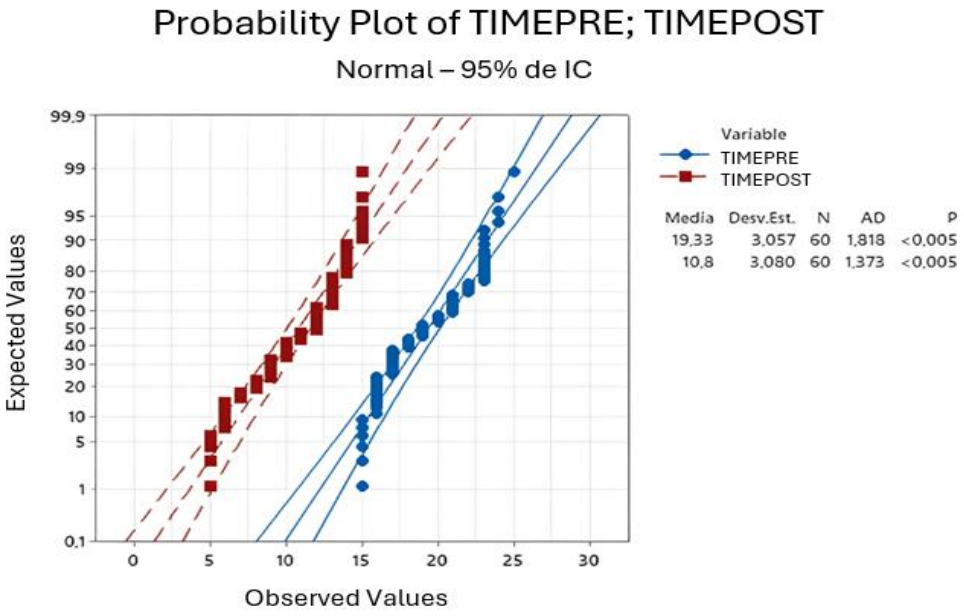


Figure 6. Test for normality of the indicator appointment recording time

As shown in Table 8 and Figure 6 since the sig. of the pretest (0.000) and the sig. of the posttest (0.001) are less than 0.05, it is stated that the data do not have a normal distribution. Table 9 shows that, after having performed the Wilcoxon non-parametric test, the significance value is equal to 0.000, this being the limit value to accept the research hypothesis. Therefore, the mobile application positively influences the time of appointment management in a specialized dental center.

Table 9. Wilcoxon test of indicator 1

	Test statistics[a]
	Appointment recording time - pre and - post
Z	-6.741[b]
Asymp. Sig. (2-tailed)	.000
a. Wilcoxon signed ranks test	
b. Based on negative ranks	

5.2. KPI 2: "number of patients presented to the appointment"

In this section, a descriptive analysis was performed for the indicator "number of patients presented to the appointment", the comparison between the pre-appointment time and post-number of patients present to the appointment, as shown in Table 10. Then the histogram was made for the pre and post-attendance of the patients to their appointments, shown in Figure 7.

Table 10. Indicator frequency of medical appointment attendance

		Attendance pre	Attendance post
N	Valid	60	60
	Lost	0	0
Mean		4.55	5.35
Median		5.00	5.00
Mode		6	3
Desvest		1.126	1.676
Varience		1.269	2.808
Minimum		3	3
Maximum		6	8
Sum		273	321
Percentile	25	4.00	4.00
	50	5.00	5.00
	75	6.00	7.00

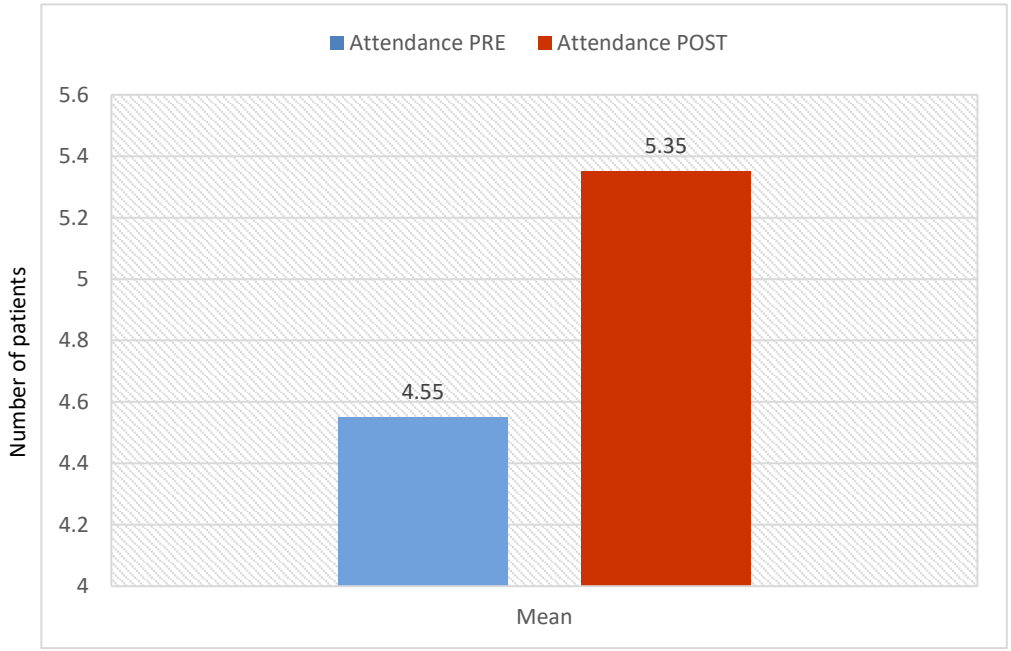


Figure 7. Histogram pre-test and post-test of the indicator number of patients presented to the appointment

According to the results shown in Table 10 and Figure 7, for the level of assistance with the implementation indicator, a mean value of 4.55 was obtained in the pre-test and 5.35 for the post-test. These results reflect an increase of 17.58%. Next, the normality test will be carried out as shown in Table 11. Then, the normality test of the indicator of the number of patients presented to the appointment was performed as shown in Figure 8.

As shown in Table 11 and in Figure 8 the sig. of the pre-test is 0.000 and the sig. of the post-test is 0.000. Where both values are less than 0.05, then it is stated that the data does not have a normal distribution. About what is observed in Table 12, using the Wilcoxon non-parametric test. There is a significant level equal to 0.004, which is less than 0.005, the limit value to see if the research hypothesis is accepted. So, the mobile application positively influences the fulfillment of appointments at the specialized dental center.

Table 11. Test normality of indicator 2

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Stadistic	gl	Sig.	Stadistic	gl	Sig.
Attendance pre	.172	60	.000	.856	60	.000
Attendance post	.140	60	.005	.913	60	.000

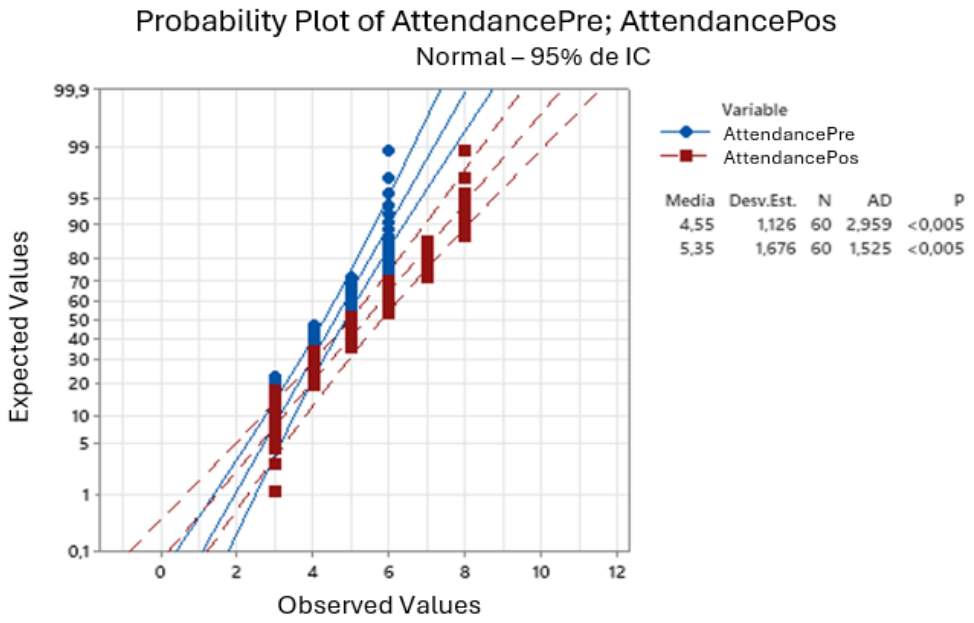


Figure 8. Test for normality of the indicator Number of patients presented to the appointment

Table 12. Wilcoxon test of indicator 2

	Test statistics[a]
	Patients presented - pre and patients presented - post
Z	-2.872[b]
Asymp. Sig. (2-tailed)	.004

*a. Wilcoxon signed ranks test
*b. Based on negative ranks

5.3. KPI 3: "leve of satisfaction"

In this section, with data extracted from the SPSS Software Version 21, the comparison was made between the level of satisfaction. Making a comparison between pre and post-assistance can be seen in Table 13. Then the histogram was made for the pre and post-level of satisfaction shown in Figure 9.

According to the results shown in Table 13 and Figure 9, for the indicator Level of satisfaction with the implementation, in the pretest, a mean value of 0.20 was obtained and for the posttest, it was 0.33. These results indicate an increase of 65%.

About what is observed in Table 14, using the MacNemar test. There is a significant level equal to 0.041, which is less than 0.005, the limit value to see if the research hypothesis is accepted. It is concluded that the mobile application positively influences the satisfaction proposed in the specialized dental center.

Table 13. Indicator frequency medical appointment attendance

		Satisfaction_pre_test	Satisfaction_post_test
N	Valid	60	60
	Lost	0	0
Mean		.20	.33
Median		.00	.00
Mode		0	0
Desvest		.403	.475
Varience		.163	.226
Minimum		0	0
Maximum		1	1
Sum		12	20
Percentile	25	.00	.00
	50	.00	.00
	75	.00	1.00

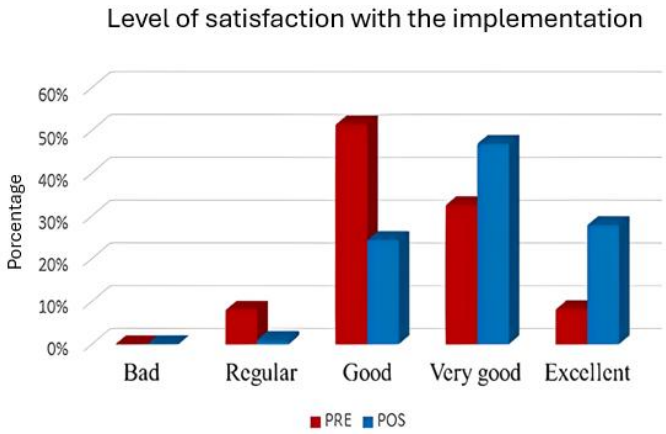


Figure 9. Histogram pre-test and post-test of the indicator level of satisfaction with the implementation

Table 14. McNemar test of indicator 3

	Test statistics[a] Grade of satisfaction - pre and grade of satisfaction - post
N	60
Asymp. Sig. (2-tailed)	.041[b]

*a. McNemar test
*b. Binomial distribution used

6. CONCLUSION

The development of a mobile application to optimize appointment management in a specialized dental center has several relevant implications. Firstly, it improves the patient's experience by facilitating the booking, modification and cancellation of appointments in real time, reducing waiting times and avoiding administrative errors. It also optimizes the efficiency of the clinical staff by automating the management of the agenda and ensuring greater accuracy in monitoring the schedules and availability of specialists.

After examining the results, it is concluded that: the mobile application has a positive influence on the appointment management time in the dental center, since it allowed a reduction in the registration time of appointments that come to the clinic, thus achieving the expected objectives of this research. Likewise, it is determined that the mobile application has a positive influence on the fulfillment of appointments at the dental center, since it allowed an improvement in the number of patients who attend their appointments, thus achieving the objectives expected in this research. Finally, it is concluded that the mobile application has a positive influence on the proposed satisfaction in the dental center since it allowed an increase in the degree of satisfaction on the part of the users, with which the objectives expected in this research were achieved.

As for future work, the application could be integrated with clinical management systems to link medical records and procedures, allowing both patients and dentists to have more efficient access to information. Other improvements could include automatic appointment reminders, integration with electronic payments, post-treatment follow-up through notifications, and even implementing a telemedicine system for remote consultations. In addition, the application could incorporate data analytics to optimize the distribution of appointments according to demand, further improving the productivity of the dental center.

ACKNOWLEDGMENTS

To the Universidad Privada del Norte for providing us with the facilities to carry out this research.

FUNDING INFORMATION

Authors state no funding involved.

AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Joel Urbina-Novoa	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
Michael Cabanillas-Carbonell	✓	✓	✓	✓	✓			✓	✓	✓		✓	✓	

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

DATA AVAILABILITY

This study is a systematic review of literature. All data analyzed during this study are derived from previously published sources, which are cited in the manuscript. No new data were generated or collected by the authors for this review.

REFERENCES

[1] S. Rashid and A. Nemati, "Human-centered IoT-based health monitoring in the Healthcare 5.0 era: literature descriptive analysis and future research guidelines," *Discover Internet of Things*, vol. 4, pp. 1-13, 2024, doi: 10.1007/s43926-024-00082-5.

[2] X. Pan, N. Geng, and X. Xie, "Appointment scheduling and real-time sequencing strategies for patient unpunctuality," *European Journal of Operational Research*, vol. 295, no. 1, pp. 246–260, Nov. 2021, doi: 10.1016/J.EJOR.2021.02.055.

[3] World Health Organization, "Implementing Health in All Policies: a pilot toolkit," Geneva, Oct. 2023, [Online]. Available: https://iris.who.int/bitstream/handle/10665/366435/9789240057128-eng.pdf?sequence=1isAllowed=y.

[4] E. Takano *et al.*, "User Experience of Older People While Using Digital Health Technologies: A Systematic Review," *Applied Sciences*, vol. 13, no. 23, 2023, doi: 10.3390/app132312815.

[5] S. Chaudhry, F. Batool, A. H. Muhammad, and A. Siddique, "Designing an online appointment system for semiliterate users," *Intelligent Automation and Soft Computing*, vol. 28, no. 2, pp. 379–395, 2021, doi: 10.32604/iasc.2021.016263.

[6] Z. Ghafar, "Digital Technologies in Health Care: A Comprehensive Review of Current Status and Future Perspectives," *International Journal of Applied and Scientific Research*, vol. 2, no. 3, pp. 353–370, Mar. 2024, doi: 10.59890/ijasr.v2i3.1558.

[7] V. Pérez-Jover, M. Sala-González, M. Guilabert, and J. J. Mira, "Mobile apps for increasing treatment adherence: Systematic review," *Journal of Medical Internet Research*, vol. 21, no. 6, 2019, doi: 10.2196/12505.

[8] T. E. Ali, F. I. Ali, P. Dakić, and A. D. Zoltan, "Trends, prospects, challenges, and security in the healthcare internet of things," *Computing*, vol. 107, no. 1, Jan. 2025, doi: 10.1007/s00607-024-01352-4.

[9] M. Cabanillas-Carbonell, "Mobile Application to Improve the Follow-up and Control Process in Patients with Tuberculosis," *International Journal of Interactive Mobile Technologies (iJIM)*, vol. 18, no. 03, pp. 75–87, Feb. 2024, doi: 10.3991/IJIM.V18I03.46875.

[10] E. A. Patel, T. A. Poulson, M. Shah, and A. A. Jagasia, "Evaluation of Wait Times for Otolaryngology Appointments in Illinois," *OTO Open*, vol. 7, no. 3, pp. 1-7, Jul. 2023, doi: 10.1002/OTO2.63.

[11] B. Zhu, C. W. Hsieh, and Y. Mao, "Addressing the Licensed Doctor Maldistribution in China: A Demand-And-Supply Perspective," *International Journal of Environmental Research and Public Health 2019*, vol. 16, no. 10, pp. 1-19, May 2019, doi: 10.3390/IJERPH16101753.

[12] T. Niu *et al.*, "A Review of Optimization Studies for System Appointment Scheduling," *Axioms*, vol. 13, no. 1, pp. 1-30, Dec. 2023, doi: 10.3390/axioms13010016.

[13] C. Saltzmann and S. Boenigk, "Blood donors' usage intentions of donation appointment-scheduling systems during the COVID-19 pandemic and beyond," *Journal of Philanthropy and Marketing*, vol. 27, no. 3, Aug. 2022, doi: 10.1002/nvsm.1756.

[14] J. Morales, F. Silva-Aravena, and P. Saez, "Reducing Waiting Times to Improve Patient Satisfaction: A Hybrid Strategy for Decision Support Management," *Mathematics*, vol. 12, no. 23, Dec. 2024, doi: 10.3390/math12233743.

[15] A. Hamdan *et al.*, "The Impact of the Online Patient Appointment System on the Quality of Health and Medical Services," *Applications of Artificial Intelligence in Business, Education and Healthcare*, Jul. 2021, pp. 239–253, doi: 10.1007/978-3-030-72080-3_14.

[16] G. Güç, M. Gedik, C. Çilgin, and T. T. Yaman, "Process Management and Improvement in Health Services: A Hospital Appointment System Example," *Journal of Health Systems and Policies*, vol. 5, no. 1, pp. 11–40, Jun. 2023, doi: 10.52675/jhesp.1257436.

[17] N. Sutarsa, P. A. S. Astuti, M. Choy, and M. Moore, "COVID-19 Pandemic: Opportunity to Accelerate e-Health in Indonesia," *Public Health and Preventive Medicine Archive*, vol. 8, no. 1, pp. 1–3, Aug. 2020, doi: 10.53638/PHPMA.2020.V8.I1.P01.

[18] S. M. Lee and D. H. Lee, "Opportunities and challenges for contactless healthcare services in the post-COVID-19 Era," *Technol Forecast Soc Change*, vol. 167, pp. 1-10, Jun. 2021, doi: 10.1016/J.TECHFORE.2021.120712.

[19] L. Schiffer, "Use and preferences regarding internet-based health care delivery in patients with chronic kidney disease," *BMC Medical Informatics and Decision Making*, vol. 21, no. 1, 2021, doi: 10.1186/s12911-020-01375-9.

[20] M. S. Sheela and C. A. Arun, "Hybrid PSO–SVM algorithm for COVID-19 screening and quantification," *International Journal of Information Technology (Singapore)*, vol. 14, no. 4, pp. 2049–2056, Jun. 2022, doi: 10.1007/s41870-021-00856-y.

[21] D. Rajan, K. Rouleau, J. Winkelmann, M. Jakab, D. Kringos, and F. Khalid, "Implementing the primary health care approach Global report on primary health care," World Health Organization, May. 2024, [Online]. Available: https://iris.who.int/server/api/core/bitstreams/b745eb7e-1db8-4a85-8f48-c2cfc154dedb/content.
[22] V. Akshay, A. Kumar S., R. M. Alagappan, and S. Gnanavel, "BOOKAZOR - an Online Appointment Booking System," in *2019 International Conference on Vision Towards Emerging Trends in Communication and Networking (ViTECoN)*, Vellore, India, 2019, pp. 1-6, doi: 10.1109/ViTECoN.2019.8899460.
[23] R. Thirupathieswaran, C. R. T. S. Prakash, R. S. Krishnan, K. L. Narayanan, M. A. Kumar, and Y. H. Robinson, "Zero Queue Maintenance System using Smart Medi Care Application for COVID-19 Pandemic Situation," in *Proceedings of the 3rd International Conference on Intelligent Communication Technologies and Virtual Mobile Networks, ICICV*, 2021, pp. 1068–1075, doi: 10.1109/ICICV50876.2021.9388454.
[24] M. M. García, J. R. M. Reyes, R. P. Zúñiga, and S. R. Cabral, "MORE: Health care System. Benefits for students of the subject Software Engineering and the community with a mobile application for medical services," *RIDE Revista Iberoamericana para la Investigación y el Desarrollo Educativo*, vol. 11, no. 21, 2020, doi: 10.23913/ride.v11i21.773.
[25] X. Fan, J. Tang, C. Yan, H. Guo, and Z. Cao, "Outpatient appointment scheduling problem considering patient selection behavior: data modeling and simulation optimization," *Journal of Combinatorial Optimization*, vol. 42, no. 4, pp. 677–699, Nov. 2021, doi: 10.1007/s10878-019-00487-x.
[26] A. Odeh, R. Abdelhadi, and H. Odeh, "Medical patient appointments management using smart software system in UAE," *2019 International Arab Conference on Information Technology (ACIT)*, Al Ain, United Arab Emirates, 2019, pp. 97-101, doi: 10.1109/ACIT47987.2019.8991064.
[27] N. A. Baba, A. Mohammed, S. S. Yahaya, A. S. Babaa, and N. A. Baba, "Development of An Intelligent Chatbot For Patient Appointment Booking System," *International Journal of Engineering and Information Systems (IJEAIS)*, vol. 8, no. 10, pp. 55–65, Oct. 2024.
[28] E. L. Cano, J. M. García-Camús, J. Garzás, J. M. Moguerza, and N. N. Sánchez, "A Scrum-based framework for new product development in the non-software industry," *Journal of Engineering and Technology Management*, vol. 61, p. 101634, Jul. 2021, doi: 10.1016/J.JENGTECMAN.2021.101634.
[29] N. Timkyw, J. M. Bournissen, and M. C. Tumino, "Scrum as a Methodological Tool for Learning Programming (in Spanish: *Scrum como Herramienta Metodológica para el Aprendizaje de la Programación*," *Revista Iberoamericana de Tecnología en Educación y Educación en Tecnología*, no. 26, pp. 81-89, Oct. 2020, doi: 10.24215/18509959.26.e9.
[30] K. Schwaber and J. Sutherland, "The Definitive Guide to Scrum: The Rules of the Game," 2020.

BIOGRAPHIES OF AUTHORS

Joel Urbina-Novoa Bachelor of Computer Systems Engineering from the Universidad Privada del Norte - Peru, with experience in the development of software projects and technical support services. His professional focus has been on information technology management for the improvement of business processes, including the development of mobile applications related to the research topic. He can be contacted at email: N00153480@upn.pe.

Michael Cabanillas-Carbonell Senior member IEEE. Engineer and master's in systems engineering, Lima, Perú, Doctorate in Systems Engineering and Telecommunications at the Polytechnic University of Madrid, Madrid España. President of the chapter of the Education Society IEEE-Peru. Conference Chair of the Engineering International Research Conference IEEE Peru EIRCON. Research Professor in Universidad Privada del Norte, Lima Perú. Specialization in software development, artificial intelligence, machine learning, business intelligence, and augmented reality. He can be contacted at email: mcabanillas@ieee.org.