Location-based Mobile Application for Blood Donor Search

Orlando Iparraguirre-Villanueva[1], Fernando Sierra-Liñan[2], Michael Cabanillas-Carbonell[3]
Facultad de Ingeniería y Arquitectura, Universidad Autónoma del Perú, Lima, Perú[1]
Facultad de Ingeniería, Universidad Privada del Norte, Lima, Perú[2]
Vicerrectorado de Investigación, Universidad Norbert Wiener, Lima, Perú[3]

***Abstract*—Technological advances and the massive use of mobile devices have led to the exponential evolution of mobile applications in the health sector. Blood donation centers frequently suffer blood shortages due to lack of donations, which is why blood donation requests are frequently seen on social networks for blood donors in urgent need of a transfusion of a specific blood group. Mobile applications for blood donation are crucial in the health sector, since it allows donors and blood donation centers to communicate immediately to coordinate with each other, minimizing the time to perform the donation process. The present work was to develop a location-based mobile application for the search of blood donors, with the objective of increasing the number of donors, having a greater population reach, and reducing the time to search for blood donors. The results obtained show a significant increase of 39.58% in the number of donors, a reduction of 53.2% in the search time, and a greater population reach.**

***Keywords*—Blood banks; location; mobile applications; donor; applicant; blood bank; mobile apps**

I. Introduction

Donating blood is helping to save the lives of those who need a transfusion in a selfless and supportive way. Worldwide, 118.5 million blood donations are collected, 40% of which are in high-income countries [30]. In Peru, approximately 270 thousand units of blood are needed per year to guarantee the normal supply of this resource in the blood donation centers of the Ministry of Health. In donation campaigns, thousands of units of blood are collected from donors, although much more are needed to meet the demand of applicants [1] [2]. Deterrents and motivations for voluntary blood donation may differ by age and ethnicity [3]. Blood donation centers often suffer from shortages, so it is the applicants who look for their blood donor, often without success, therefore, strategies for effective donor recruitment and retention are required. Blood donation centers still use traditional methods for donor recruitment, such as blood donation campaigns, word of mouth, social networks, etc., although they are still valuable, but they are becoming less and less effective [4]. In addition, the Ministry of Health's blood donation centers work in isolation, without integration with other health institutions, which affects the quality of service. In this context, information technologies and smartphones have become an ally for blood donation [5][29].

The present research proposes the development of a location-based mobile application for blood donor search (DONAPE), for which the mobile application provides a direct location-based channel between blood seekers and blood donation centers. Achieving to increase the number of donors, improve the place of origin (geographical location) of donors and improve the search time.

The article is organized as follows. Section 2 describes the main related studies that have been conducted in the field of location-based blood donation and mobile technology. Section 3 presents the location-based mobile application development methodology and research method. Section 4 develops the case study. Section 5 describes and analyzes the results. Section 6 presents a brief discussion. Finally, Section 7 presents the conclusions.

II. Review of the Literature

Currently, in order to guarantee the required supply of blood units, it is necessary to focus efforts on donor recruitment and retention. Therefore, it is important to know the characteristics of donors, their motives and deterrents to voluntary donation. In this context, technological progress has played a very important role in blood donation; technology has made it possible to streamline and automate processes. In this sense, a set of works related to the search for blood donors has been reviewed.

In [6] developed a mobile application for Android, which offers a simple and fast approach to searching for blood, where they can easily find donor and recipient data through their cell phones. While researchers at [7][8] developed cloud-based web applications to administer and manage the health system's blood units. These applications allow blood units to be allocated according to the severity of the case, availability of types and quantities. Along the same lines, the research work [9] proposed a method for allocating blood units, using a mobile application, which utilized a real-time hybrid algorithm to develop the blood unit allocation operation. In [10][11] [12][13] web and mobile applications were developed to manage blood donation, allowing to register, schedule, receive notifications and access information, synchronizing blood donation centers with emergency centers, to verify the availability of blood needed and to send a request to the nearest blood donation center.

Web applications for blood donation have also been developed using new technologies such as blockchain and learning algorithms. In [14][15] web applications were developed using blockchain technology, applying machine

learning algorithms to develop and evaluate models for classifying blood donors as returnees and non-returnees. In [16] [17] [18] proposed web-based applications to manage blood donation campaigns, with the aim of collecting and organizing data. The researchers at [19][20] developed web applications to monitor and investigate the risks involved with donors before and after the donation process.

Although previous studies considered many aspects of the blood donation process, each of them exclusively addressed issues related to web or mobile applications as managers for blood donation, forgetting the importance of managing the location of the donor and applicant. The main reason for this research is that through the mobile application we can manage the location of both the donor and the applicant to make and improve the blood donation service.

III. Methodology

For the present work we chose to use the agile Scrum method to develop the project prototype. Scrum is an adaptive, iterative, fast, flexible and efficient framework. Scrum ensures transparency in communication and creates an environment of collective responsibility and continuous progress [21]. This method has 5 phases: initiation, planning and estimation, implementation, review and retrospective and launch, for the development of this project we will work with four processes, which are described below.

A. Sprint Planning

In this process, meetings are held to define the user stories, estimate the tasks and create the sprint backlog, and a time-box of eight hours is assigned during a month-long sprint [22]. In this process the Scrum team decides to complete the selected items in the prioritized product backlog to meet the sprint goal.

B. Sprint Development Work

In this process, the Sprint Backlog is implemented, no changes are made that affect the objective of the sprint, quality objectives are ensured, the scope is renegotiated with the product owner and the development team as it is developed. [23]. In this process it is possible to preview the inspection and the adaptation of the progress towards the goal according to the schedule of activities.

C. Sprint Review

The sprint review is conducted to demonstrate and validate the sprint, the Scrum Team presents the deliverables of the current sprint to the Product Owner. The Product Owner reviews the product increment against the agreed acceptance criteria and accepts or rejects the completed user stories [23].

D. Sprint Retrospective

In this process, a 4-hour meeting is held in a one-month sprint, and is developed as part of the sprint retrospective process. During this meeting, the Scrum team meets to review and reflect on the previous sprint in relation to the processes that were followed, the tools used, the collaboration and communication mechanisms, as well as other aspects of interest to the project [24].

A strength of Scrum lies in the use of cross-functional, organized and empowered teams that divide their work into short, concentrated work cycles called sprints.

The main characteristics of mobile applications are high performance and availability, which is why the client layer is developed offline, as shown in the architecture in Fig. 1.

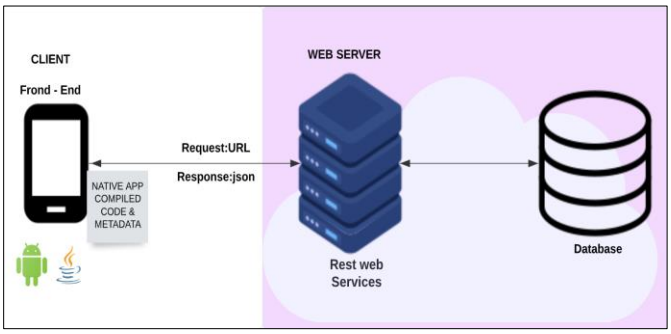

Fig. 1. Mobile Application Architecture.

IV. Case Study

This section details the development procedure of the mobile application prototype, following the life cycle methodology mentioned above. Likewise, Table I describes the tools to be used in the development of the case.

TABLE I. Tools for Prototype Development

Software	Description
Android Studio	Development environment for the Android platform
Firebase	NoSql database
GitHub	Repository for version control
Figma	UI and UX design application
Play store	Online store service to distribute the mobile application.
Jira	Online software to manage project tasks.

The Scrum cycle starts with a stakeholder meeting, then the product owner develops the prioritized product backlog. Each sprint starts with a planning meeting where the prioritization of the stories is considered, and generally lasts from one to six weeks. Then, the sprint planning and time estimation for each of the user stories to be implemented is done.

A. Planification Del Sprint

In this section the analysis and identification of the requirements for the elaboration of the User Epics is performed, together with the descriptions of the functionalities that the mobile application will have, which are elaborated between the product owner and the Scrum team, and that can be improved during the project life cycle. This is an agile way to manage requirements without elaborating large amounts of documentation [25]. Table II describes the user epics that will be implemented for the development of the case study.

TABLE II. USER EPICS

#	Description
ADS-1	Manage the authentication module: The mobile application should have a login interface with security token for user registration and authentication
ADS-2	Manage the notification module: The mobile application must have the option of notifications to indicate to the user of requests.
ADS-3	Manage Google maps module: The mobile application must incorporate Google maps technology for real-time search of donors or applicants based on location.
ADS-4	Manage the health center location module: The mobile application, through geolocation, should locate the closest health centers for the blood donation process.
ADS-5	Manage the reporting module: The mobile application must show the available or connected donors, as well as the list of applicants..

Time estimation: In this phase the Scrum team decides to complete the prioritized product backlog, assigning the duration, priority and complexity for each of the user stories. There are many tools to estimate user stories, for this case Planing Poker is used to estimate and indicate the complexity whose value only makes sense to the development team [26]. The project estimate resulted in nine weeks, as shown in Table III.

TABLE III. PRODUCT BACKLOG

Description	*Duration Weeks*	*Story point estimate*	*Priority*	*Epic*
Sprint 1: User authentication module	***2 weeks***	***40***		
Implement the login interface		16	highest	ADS-1
Implement the interface for the registration of new users (donors and applicants).		14	highest	ADS-1
Implement the interface for password recovery		10	highest	ADS-1
Sprint 2: notification module	***2 weeks***	***35***		
Implement the notifications component in the startup interface		18	high	ADS-2
Implementing the tray where notification messages are received		17	high	ADS-2
Sprint 3: geolocation module	***3 weeks***	***40***		
Implement the google maps service in the application.		14	highest	ADS-3
Implement the real-time search option with the google maps service.		16	highest	ADS-3
Implement the search for the nearest health centers using geolocation.		10	highest	ADS-4
Sprint 4: reporting module	***2 weeks***	***33***		
Implement reports of available donors and applicants by geographic location.		17	medium	ADS-5
Implementing donor and applicant reports that have been attended to		16	medium	ADS-5

Project scope: understood as the sum of all product requirements and all work necessary to develop the final product/service [24]. The functionalities originate from the set of requirements established and analyzed together with the product owner. Therefore, in order to know the fulfillment of the project scope, the degree of progress of each of the user stories of the product backlog is verified, in order to know if the implementation is being carried out as planned.

Fig. 2 shows the hours that the team takes to develop the user story points, in order to verify in greater detail the degree of progress in the sprint estimates.

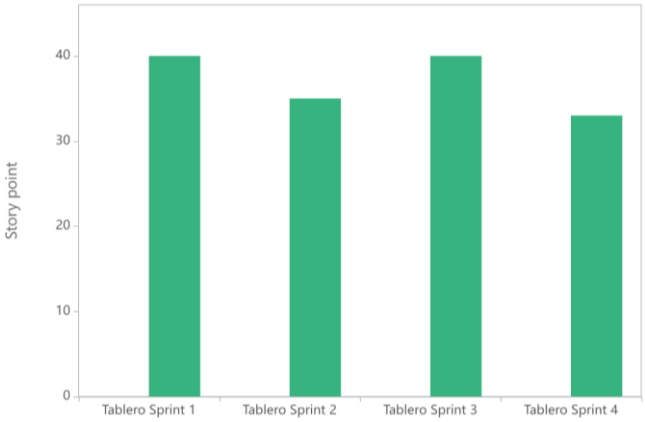

Fig. 2. Estimation of each Sprint.

B. Sprint Development

In this process, the following sprints are developed:

1) Sprint 1 (user authentication): In this Sprint the interface for the login Fig. 3, interface for the registration of new users (donor or applicant) and password recovery is developed. The user must have the access credentials to log in, otherwise, he/she will have to register his/her data as requested in the form. If the user forgets his/her password, the recovery process is performed.

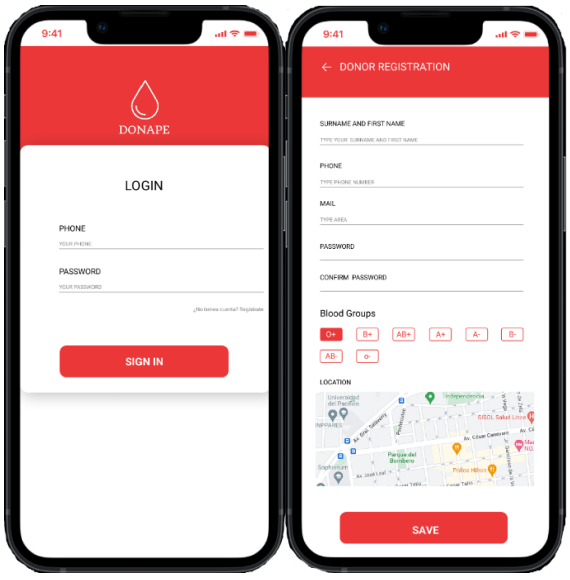

Fig. 3. Donor Login and Registration.

2) Sprint 2 (notification module): In this second Sprint, the interface for the notifications module was implemented. As shown in Fig. 4, this component has two sections: 1 for the inbox, and another one located in the upper right part of the startup interface.

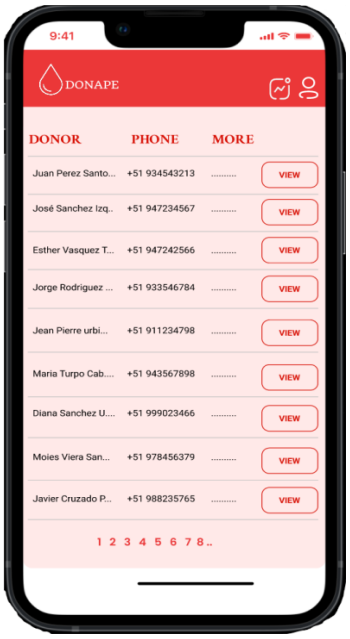

Fig. 4. Notifications and Tray.

3) Sprint 3 (geolocation module): In this sprint, the Google maps service is incorporated into the prototype, in order to search for donors and locate donation centers, as shown in Fig. 5. In the first interface of Fig. 5, the applicant searches for blood donors. In principle, the algorithm performs the search based on the location of the applicant, prioritizing the proximity of the donor. Once the donor has been located, the applicant searches for the health center that has a blood bank, using the second interface in Fig. 5.

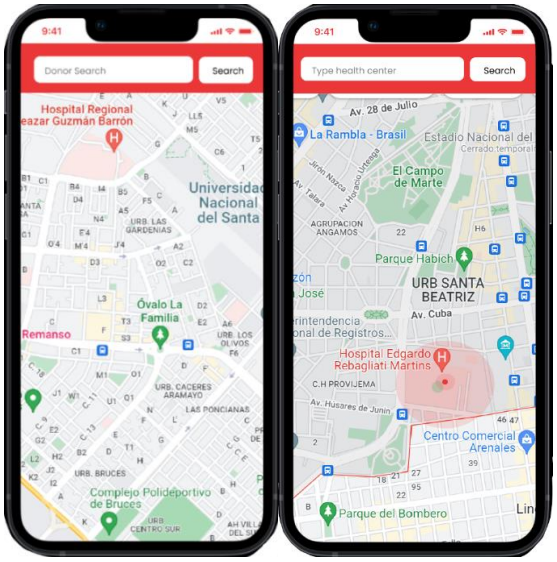

Fig. 5. Search for Donors (a) and Blood Donation Centers (b).

In the interfaces of Fig. 5(a), the first interface is where the applicant searches, chooses the donor and can contact immediately. (b) The second interface is used to search for the blood donation center closest to the interested parties, in order to carry out the blood transfusion process. The donor will be able to cancel the request through the application, in case they do not reach a mutual agreement.

4) Sprint 4 (reporting module): In this sprint the donor reports are developed, where the names, city of origin, cell phone number, date of last donation and blood type can be displayed, as shown in Fig. 6.

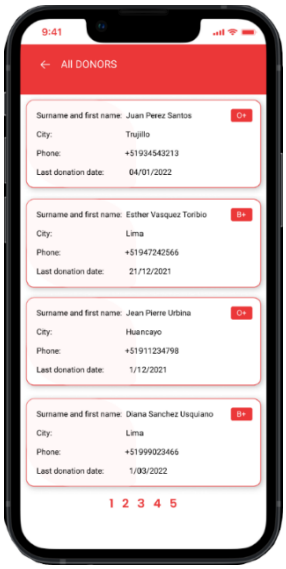

Fig. 6. Donor Report.

C. Sprint Review

After the development of each Sprint, we proceed with the review, for this Scrum Team members and Stakeholders participate in the review of the sprint to accept the deliverables, the review time is two to three hours. At this stage the Scrum Team demonstrates the achievements of the sprint, specifying each of the new features. This provides an opportunity for the product owner to inspect in detail what has been completed so far and determine if changes should be applied to the sprint.

D. Sprint Retrospective

The retrospective is the last step in a sprint. All Scrum team members attend this meeting, which is organized by the Scrum mater, this meeting together with the product owner, discusses important elements for future actions. This retrospective meeting covers both what went wrong and what went right. It also evaluates the process followed in the development of the sprints, tools, among other elements. It is also a space for new ideas or methods in order to continue improving the process and promoting good practices.

To demonstrate the results of the implementation of the mobile application, it was tested for 20 days. The design used was pre-experimental, with a pre-test and a post-test, since the online method was used (1). Table IV shows the elements of the design.

TABLE IV. DESCRIPTION OF PRE-EXPERIMENTAL ELEMENTS

Elements (1)	Description
Ge	Experimental group: the study is carried out in the Dlima laboratory for 20 days.
O_1	It is the measurement before implementing the mobile application. Pre-test data measurement: experimental group.
X	Mobile application = object to be tested
O_2	Measurement of post-test data: experimental group.

G_e O_1 X O_2

V. RESULTS

This section describes the results related to the development of the research within the case study. In Peru there is no culture of voluntary blood donation, the need is permanent and the numbers required to cover the demand are high [1].

TABLE V. RESULTS OBTAINED IN THE PRE-TEST AND POST TEST

#Dia	KPI-1		KPI-2		KPI-3 (Horas)	
	Pre	Post	Pre	Post	Pre	Post
1	0	3	----	Piura – Olivos- Surco	8	4
2	0	2	----	Lince – Cercado	8	4
3	2	4	Lince - Surco	Trujillo – 2 Cuzco- SJL	6	3
4	1	2	Breña	Olivos – Huacho	8	4
5	1	2	Lince	Arequipa – Breña	8	4
6	2	2	Olivos -SJL	Breña – Tarapoto	4	4
7	1	1	Cercado	Olivos	8	3
8	2	2	SJL-Lima	Trujillo – Chimbote	4	4
9	2	2	Lince - olivos	Piura – SJL	4	3
10	2	3	Comas-Breña	Olivos – Breña – Piura	4	3
11	2	3	Comas-surco	Lince – olivos -Trujillo	4	3
12	3	5	SJL-olivos-lince	Arequipa – Cercado – Lince – Comas – SJL	4	2
13	2	2	Lince - breña	Chimbote - Olivos	4	2
14	2	3	Cercado - Surco	Cercado - Piura -Trujillo	4	2
15	3	3	Comas - olivos - SJL	Surco-Comas - Olivos	3	3
16	2	4	Lince - cercado	Cuzco - Surco – Arequipa – Chimbote	4	2
17	1	5	Cercado	Tarapoto – Breña – Surco-Piura- Comas	8	1
18	2	3	Surco - olivos	Trujillo-Comas - SJL	4	3
19	1	3	Lince	Breña – Olivos – Cuzco	8	2
20	2	3	SJL - Comas	Trujillo – Piura - Breña	4	2

For the case study, we worked with the Dlima laboratory, a blood bank that offers a modern and highly reliable blood transfusion system. Since the beginning of the COVID-19 state of emergency, blood donations have dropped by more than 70% due to fear of infection [27]. Since then, the laboratory implemented a set of strategies to search for donors and maintain the blood bank reserves and promote the culture of voluntary donation even in the context of a pandemic. One of the strategies was the proposal to develop a location-based mobile application to search for blood donors, with the following indicators: increase the number of donors (KPI-1), place of origin (geographical location) of the donors (KPI-2) and improve the search time (KPI-3). It is known that screening tests for hepatitis B and C, HIV, HTLV I and II, Chagas disease and syphilis are performed prior to blood transfusion. In our environment there are still prejudices regarding blood donation, therefore, the laboratory implemented a reward program that consists of performing a blood test known as "complete blood count" for any altruistic donor who decides to use the mobile application to donate blood. The data collection (Table V) for the pre-test measurement used a record type card and for the post-test the automated record of the mobile application.

Table VI shows the average results for each KPI; these results were derived from Table V. It should be noted that the districts of Lince, Breña, Cercado, Surco, Comas, Olivos and JSL belong to the city of Lima.

Fig. 7 shows that the average of KPI-1 has improved in the number of donors, in KPI-3 the average indicates that the time to search for donors has been reduced, in the same line, it is observed that in KPI-2 after the implementation of the mobile application, access to other regions of the country has been achieved.

To measure the indicators in Table VI, we used the scales of time in hours, quantity and distance.

TABLE VI. RESEARCH INDICATORS

Indicator		Pre-Test	Post Test
KPI-1	Number of donors	1.65	2.85
KPI-2	Donor origin	Lima	Lima + Provincia
KPI-3	Donor search time	5.45	2.9

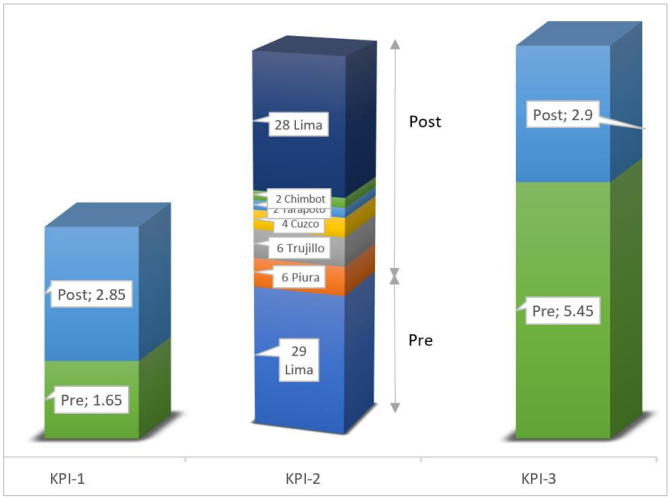

Fig. 7. Pre and Post Comparison of KPI's.

A. Results of the First Indicator (KPI-1)

Fig. 8 shows the normality test for KPI-1, where a standard deviation of 1.04 is observed with respect to the mean of 2.85 donors per day. Along the same lines, the data obtained show that the p-value is less than 0.05, which confirms that the information analyzed has a non-normal behavior.

Regarding the nonparametric Wilcoxon test (Table VII). It has an asymptotic significance level of 0.001, which is less than 0.05, which is the limit value for the acceptance of the hypothesis, therefore, it is stated that the implementation of the mobile application has a positive impact on attracting a greater number of blood donors.

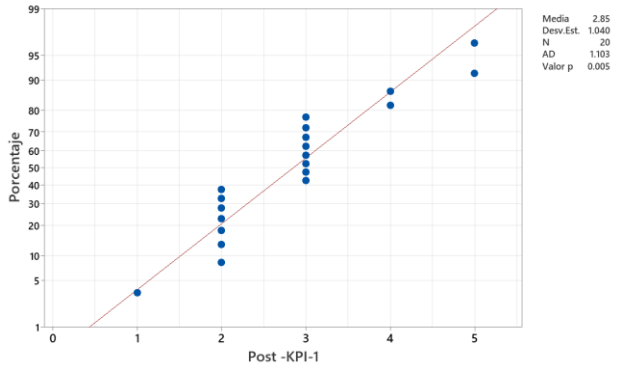

Fig. 8. Normality Test of KPI-1.

TABLE VII. WILCOXON´S TEST FOR KPI-1

Statistical test	
	PRE-TEST KPI-1 POST TEST KPI-1
Z	-3.359[b]
Sig. Asintótica(bilateral)	.001
Wilcoxon signed-rank test	
Based on positive ranges	

B. Results of the Second Indicator (KPI-2)

Fig. 9 shows the results of the second indicator, which evaluates the donors' place of origin. In the pretest, the origin of the donors belonged only to the city of Lima, including the districts (Lince, Surco, Breña, Los Olivos, SJL, Cercado and Comas), where a total of 29 blood donors were obtained. In the post test, with the use of the mobile application, a greater reach was achieved, obtaining blood donors from different cities in the country, such as: Piura, Trujillo, Cuzco, Tarapoto, Chimbote, among other districts of the city of Lima, totaling 48 blood donors. Therefore, we can affirm that after the implementation of the project, we have a positive impact on the population and a greater reach.

C. Results of the Third Indicator (KPI-3)

Fig. 10 shows the normality test for KPI-3, where a standard deviation of 0.9119 is observed with respect to the mean of 2.9 hours required to obtain a donor. In the same line, the data obtained show that the p-value is less than 0.05, which confirms that the information analyzed has a non-normal behavior.

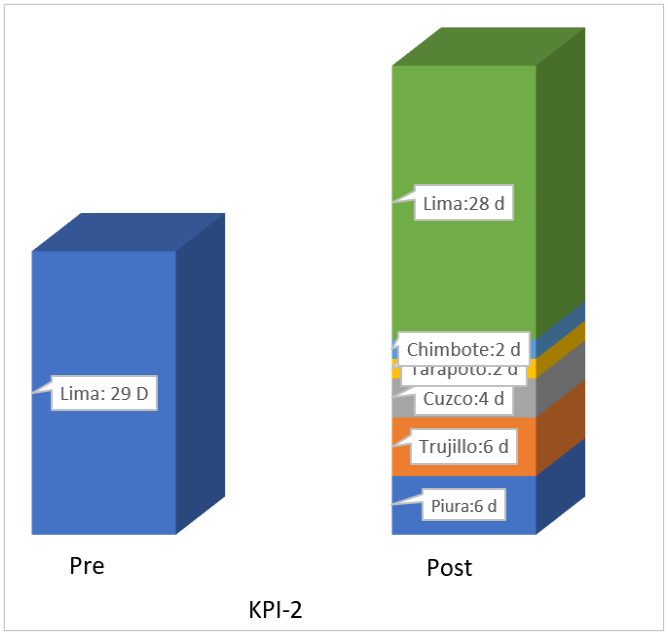

Fig. 9. KPI-2 Measurement Results.

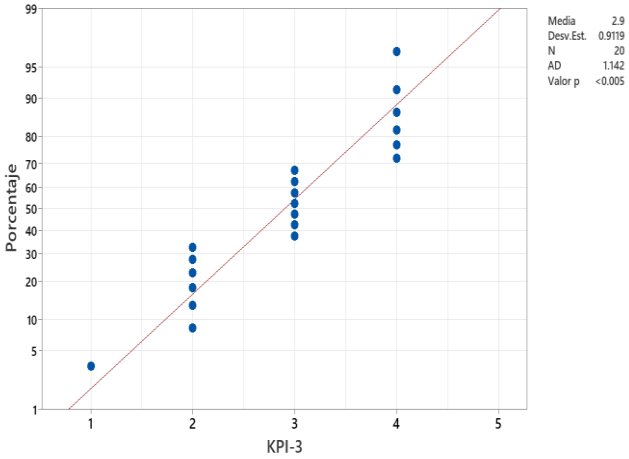

Fig. 10. KPI-3 Normality Test.

Regarding the nonparametric Wilcoxon test (Table VIII). It has an asymptotic significance level of 0.000, which is less than 0.05, which is the threshold value for the acceptance of the hypothesis, therefore, it is stated that the implementation of the mobile application has a positive impact with respect to measuring the time to recruit blood donors.

TABLE VIII. WILCOXON´S TEST FOR KPI-3

Statistical test	
	PRE-TEST KPI-3 POST TEST KPI-3
Z	-3.642[b]
Sig. Asintótica(bilateral)	.000
Wilcoxon signed-rank test	
Based on positive ranges	

VI. Discussion

About the case study: the mobile application was made with Android Studio, Firebase, among other tools such as Jira, which was used to manage user stories, allowing a controlled monitoring by both the team and the product owner. A set of works related to blood donation has been reviewed, where technology is used as an ally for this purpose. Works such as: [16][17] developed mobile applications for blood donation integrating cloud services with the purpose of promoting and facilitating blood donation. In the meantime [12][13] In their projects, they focused on the development of mobile applications to manage notifications, access donor information and synchronize with the blood banks, all of which have undoubtedly contributed to the development of this work.

About the methodology: Scrum is an agile methodology for software development, in this group there is a set of methodologies based on agility. However, the main reason why Scrum was chosen for the development of the mobile application is the short iterations known as sprints that allow early deliveries of two to four weeks and in turn a quick feedback from users and stakeholders [28]. Among other advantages and benefits of the Scrum methodology we can highlight: it helps to manage and minimize project risks, it improves the relationship between cost and benefit, it allows the development of team skills, and it works mostly with small teams.

With respect to the limitations that were found in the research work and that could have affected the results, in principle there was no list of blood donation centers authorized by the ministry, and to a lesser extent the time it took for the play store to review the mobile application.

VII. Conclusion

In this research article, a location-based mobile application was developed to search for blood donors, using the Scrum methodology, Google maps service to locate the donor and blood donation centers in real time.

After the implementation of the project, there was a significant increase in the number of blood donors by 39.58%, as well as a reduction of 53.2% in the time required to search for blood donors. The results show that donors from different cities in the interior of the country such as Piura, Trujillo, Chimbote, Cuzco and Tarapoto, representing 39.58%, however, it is important to note that the city of Lima continues to concentrate the largest number of blood donors, equivalent to 60.42% according to the case study.

The scientific contribution of this article is fundamental for the development of future work related to blood donation campaigns. With the data collected through the mobile application, it is possible to perform analytical processing, develop strategies with reward incentives to motivate blood donation, and add new functionalities so that doctors and patients can communicate.

Finally, it was demonstrated that the solution developed, manages to increase the number of blood donors, reduce the time to get donors, has greater population reach and in turn has access to the information provided by the donor, and with this to perform actions in favor of those concerned.

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