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Prototype Web Application to Reduce Time for Cross Kidney Donations in Lima, Peru

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ABSTRACT

In recent years, the delay or non-arrival of a kidney donor has led to saturation and congestion of care in the country's medical centers, claiming the lives of thousands of people. Although it is true that nowadays there are a number of people who offer to make these donations, unfortunately this number has been decreasing due to the lack of patients waiting for a prompt intervention. In this work, we used a method called Design Thinking that allowed us to analyze and plan strategically the processes involved in making an assertive match in a shorter time between donor and patient. The project was applied in Lima, Peru. In this study, compatibility was determined through cross-comparisons of analysis of donors and patients from various hospital centers, and a rapid response was provided to the health center that has been requiring it for longer than other cases. As a result, we obtained rapid interaction and communication between health centers, and a decrease in the rate of patient deaths due to this problem. As a consequence, these results would help the different hospitals, as well as the patients with more waiting time to identify a potential match in a shorter time.

Key words : Cross Donation, Design Thinking, Organ Donation, Web Application.

1. INTRODUCTION

There are quite a few people in the world waiting for a kidney transplant, and unfortunately many of them die while waiting. The Health Resources and Services Administration (HRSA), an agency of the U.S. Department of Health and Human Services, reports that more than 112,000 people in the U.S. are waiting for a kidney transplant, and that 20 people die every day waiting for an organ transplant [1]. In Peru the situation is just as critical, since Peru has one of the lowest donation rates in all of Latin America, surpassed only by Bolivia[2]. However, it have shown a slight progress as in 2019 Juan Almeida Alcantara, general director of donation, transplant and blood bank of the health ministry reported that in recent times the family refusal for donations decreased from 76% to 56%[3].

In order to carry out a research project, there are currently several methodologies that can help us to optimize the construction time of our product and improve our work structure in a strategic and efficient way. Among the most important are Scrum[4], [5], XP[6], [7] and Design Thinking[8]. Just to mention it, Scrum is the most popular agile methodology in the software industry, where several companies have been able to achieve a significant improvement in their quality and productivity [9]. Thanks to its 5 stages, it allows a work team to tackle almost any type of problem, helping to analyze it with a systemic and open approach, encouraging teamwork and retrospective work, not only among work members but also with external stakeholders (users or customers) [10]. And with its feedback phase, allowing us to evaluate the progressive level we are having as we go along, making improvements in the processes, if needed. Likewise, XP which isa traditional methodology has been evaluated, which in spite of the time continues lasting for its great advantages that it provides at the moment of approaching a project. Advantages such as the simplicity of its phases, fluid communication, repeated training of the team and constant feedback per cycle that ensures continuous improvement [6]. However, in this work Design Thinking will be used, a methodology in which the designer generates the design concept, makes the design and takes decisions in order to solve problems using experience, knowledge and contextual information[11]. The choice of this methodology is due to the fact that it offers human-based thinking, through direct observation and identification of the goals of the user or customer, to analyze the context in depth and to build design models to meet needs [12].

This research presents the management of a web application to decrease the time that a kidney donor is sought in health centers, the advantage of this application will be to evaluate the districts with a higher percentage of donors or the decrease of patients that require a donor to have a better quality of health [13]. The prototype of the application that will be presented can be executed in any health center of the capital, this allows to decipher in a matter of minutes the possible crossings of donor - patient preventing complications of health to the patient with regard to traditional searches of donors for it; the application web will allow to register a database of donors as the patients.

Our research aims to address this problem and contribute to society with a technological solution that can improve this problem and save lives by designing a prototype that will reduce the time of matching donor and patient in a kidney transplant.

Therefore, the structure of the present will be as follows: Chapter 2 will show the methodology in detail, chapter 3 will explain the case study carried out. Then, chapter 4 will show the results and discussions and chapter 5 will display the conclusions.

2. METHODOLOGY

Design Thinking is a concept that has been originated in research into the cognition of design; is not only seen as an engine of innovation promoted by designers, as it offers innovative process models and tools that serve to improve, accelerate and visualize each creative process, carried out not only by designers, but also in a multidisciplinary way in work teams [8]. In order to do an effective approach of the methodology, 5 stages have been recognized according to [14], [15], as seen in Figure 1.

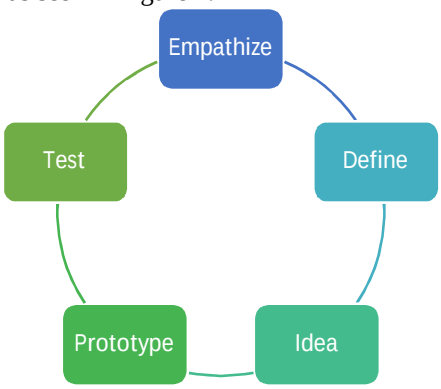

Figure 1: Design Thinking Phases

The phases of this methodology are as follows:

2.1 Empathize

In order to acquire basic knowledge about the users of the product, it is necessary to have an in-depth understanding of the needs, desires and problems they face. For this reason, in this phase, with the help of various devices such as the Golden Circle, among others, a deep analysis of the problem will be carried out, obtaining valuable information that will serve as a basis for the development of the following phases [16].

2.2 Define

The information collected is only useful when analyzed, allowing to obtain key definitions to generate ideas. In this second stage, a filtering of the important data will be carried out, which will allow us to generate conclusions that will help to understand how the problem is structured and what ideas could be used to reach the solution [16].

2.3 Idea

At this stage, the process and formulation of all ideas begin. Therefore, the concepts and assets are delivered to make prototypes and realize solutions different from the others. Absolutely all ideas are valid and the goal is to combine everything from the most common ideas to those that seem impossible [15].

2.4 Prototype

This phase is the elaboration of elements that provide information such as drawings, artifacts and objects in order to answer questions that bring us closer to the final solution. That is, it does not necessarily have to be an object but anything that can be interacted with [15].

2.5 Test

This step consists of looking for feedback and user opinions on the prototypes elaborated. It is need to take into account to make a prototype believing we are right but we must be open to evaluate any possible mistake in order to enhance them. This is the opportunity to refine the solutions and improve them. Ideally it should be evaluated and tested in the context of the user either with the real or simulated client[15].

3. CASE STUDY

3.1 Empathize

Thanks to this phase, we will be able to collect information about the problem under study. We will obtain specific data such as why, when and how often it happens, which will allow us to obtain a clearer understanding. For this reason, we will apply the Golden Circle technique.As defined by its creator Simon Sinek "the Golden Circle is a wonderful way to understand why great people have succeeded over others who have also tried and why successful companies are at the top"[17], but, as well as working in the business world, in the area of research has allowed researchers to know a certain problem, which causes, how it affects and who it affects[18].

A. Why does it happen?

Generally, organ transplants are performed when the patient progressively presents complications in some organ of his body. This can be generated by a hereditary disease, injury or by the consumption of harmful substances.

B. When and how?

Since March 2020, there have been more than 112,000 candidates on the U.S. national waiting list for organs, and while two out of every three individuals are over 50, there are about 2,000 children under 18 who remain on the waiting list [1]. This occurs when the body detects an organ that behaves unusually and alerts the body through what is known as pain. If after a while this pain persists, the body begins to reject the organ causing the discomfort causing first and second degree symptoms such as bleeding, seizures, among others; then finally immediate medical intervention is needed.

C. How often does it happen?

Even though people are usually in greater need of an organ transplant, the rate of organ donors in Peru has stagnated since 2012 with a percentage of 13% of the population able to donate organs, as shown in Figure 2. Records show that only 3.2 million Peruvians of legal age accepted to donate organs according to their national identity card, while 18.9 million refused and 2.5 million did not specify their response when their documentation was processed[19].

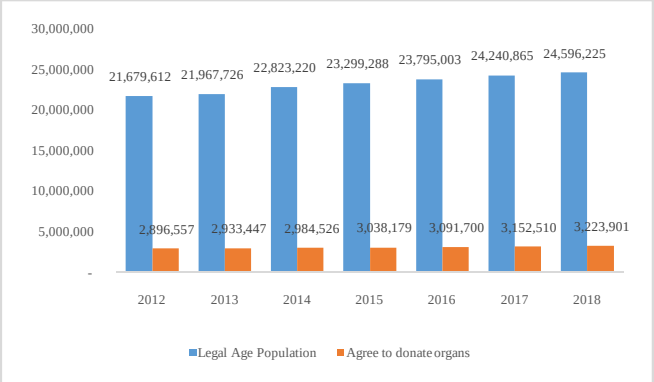

Figure 2: Organ donor rate in Peru[19]

3.2 Define

We will focus on analyzing both patient and donor data, specifically the cards that are registered at health centers. The patient card in figure 3, will serve as a support since from it we will extract the data in order to make the corresponding analysis, this will be reflected both internally and externally the web application.

Datos del Paciente		Datos Medicos	
Codigo	11029348	Ultimo control	15/03/2020
Nombres	Maria	Doctor a cargo	Luis Meroya
Apellidos	Alváro Suarez	Enfermera a cargo	Karla Ruiz
Fecha Nacimiento	18/05/1989	Seguro	Essalud
Telefono	2984767	IMC	29.8
DNI	3000292	Enfermadades	Asma, Faringitis
Sexo	femenino	Alergico a medicamento	X
Edad	31	Tipo de sangre	O+
Direccion	Av. Mexico 921, Comas	Riñon dañado	derecho
		Otro organo dañado	X

Figure 3: Patient card

On the other hand, the donor card shown in figure 4, will serve as a link to the patient's data. The medical data will be analyzed and will have to coincide with the patient's data in this way the application will have a sense of support for the medicine and an objective of correlating data.

Datos del Donador		Datos Medicos	
Codigo	55239470	Tipo de donante	Donante vivo
Nombres	Piero	Distrito de registro	Carabayllo
Apellidos	Morales Lara	Mes de atencion	Junio
Fecha Nacimiento	29/02/1987	Año de atencion	2019
Telefono	3489910	Dono otro organo	X
DNI	7782028	Seguro	SIS
Sexo	masculino	IMC	31
Edad	33	Enfermedades	X
Direccion	Av. San Felipe 211, Carabayllo	Tipo de sangre	O+
		Riñon donante	derecho
		Organo dañado	X

Figure 4: Donor card

3.3 Idea

A. Brainstorming

We elaborated diverse ideas focused on the project. Its representation is shown in Figure 5.

Figure 5: Brainstorming

B. Ideas selection

Once we have defined the general ideas, we must now discard those that are not in the plans of the project to be carried out, in order to have a set of ideas much more focused on what the purpose is, the visual representation of it is found in Figure 6.

Figure 6: Ideas selected

C. Priorities Diagram

The Eisenhower diagram can help us decide which activities are key for us, thanks to the weighting, decomposition, analysis and grouping of activities [20]. In the present case, it allows us to prioritize actions that are divided into 2 strategic quadrants, ranging from analysis of the situation in Peru, the functioning of organ donation, to the projection of the construction of the Prototype. The application of this diagram is shown in Table 1.

Table 1: Priorities Diagram

Urgent	Non-Urgent Priority
Functional status throughout the length and breadth of Peru	Operational user interface
Cross-organ donation	Web application
Social Welfare	Cloud performance

3.4 Prototype

The web application prototype was created with the function of finding patients and donors who may have a crossover relationship or compatibility for the respective transplant in the department of Metropolitan Lima, with the intention of reducing the time to find a potential donor. Bearing in mind

that the application will only register donors who have undergone the respective tests and who are suitable for the corresponding transplant, since there is a data of all the patients who require the transplant in Metropolitan Lima. Such prototype have been developed along with the well-known tool Balsamiq Mockups [21], [22] as it has demonstrated to be an interactive and user friendly tool free of charge capable of develop a prototype according to the needs of the author [23], [24].

The prototype can be seen in Figure 7, in which the user will enter the user and password, leading us to another display (Figure 8) with the registered functions and it will be disposed when pressing the buttons.

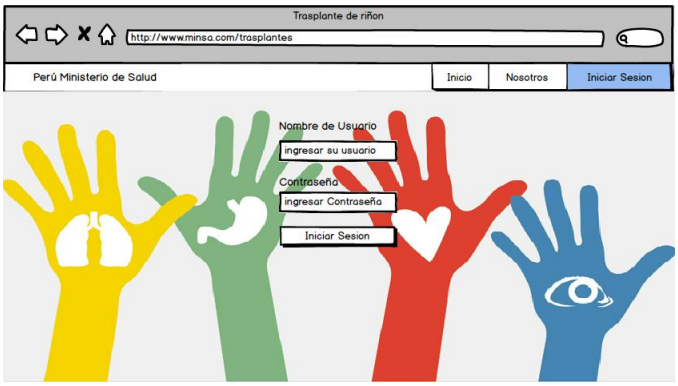

Figure 7: Home Screen

The objective of the visual information that is shown in Figure 8 is to facilitate the representation and understanding of the functions that will be given to the user.

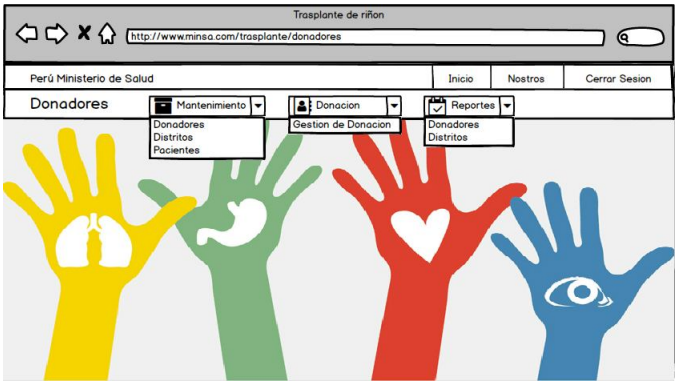

Figure 8: Main User Screen

The functionality that the user will handle in the main screen will be as shown in table 2.

Table 2: Expected functions according to users

User	Description
Administration, Patients and Donors	The user can see all the information of the registered donors or make changes to the existing data
Administration and Patients	The user can see the information of all the districts where there are donors
Administration	The user can review all information on patients who have or have not received transplants.
Administration and Donors	The user can register the data of the donor.
Administration	Here the user will be able to visualize the donors that have found compatibility with the patients, recently.
Administation	The user will be able to visualize which the districts with more compatible records are.

3.5 Test

Table 3 will measure the effectiveness and efficiency of the application through specific questions related to functionality and user comfort. From this table we can deduce problems of the application for an improvement in future versions.

Table 3: Expected functions according to users

Questions about the web application	**User A**		**User B**		**User C**		**User D**	
	Yes	***No***	***Yes***	***No***	***Yes***	***No***	***Yes***	***No***
Is the web interface easy to use?	X		X		X			X
Is the web application friendly?		X	X		X		X	
Is the web application useful in the field of health?	X		X		X		X	
Is it possible to say that the application is better than the traditional method?	X			X	X		X	
Are you likely to recommend this web application?		X	X			X	X	
Are you satisfied with the performance of the web application?	X		X		X		X	

4. RESULTS AND DISCUSSION

4.1 About the Case Study

To carry out the development of our research, it was not only enough to apply a methodology that helps to effectively structure the project, but also various tools.By comparing our work with other research, we can obtain a feedback that allows us to visualize differences and characteristics that can contribute positively, such as changes that benefit the research conducted.

For this reason a first comparison was made with the work Computerized Decision Support System for Kidney Paired Donation Program [25]. Its case study consists of developing a system that helps to make decisions in complex processes such as the Paired Kidney Transplant. Its system called KPD analyzes the composition of living organs (kidneys), performs a micro-simulation, and depending on the results, reflects a percentage of assertiveness with other samples already analyzed previously, it is worth mentioning that his process uses mathematical formulas and intelligent learning algorithm combined with data analysis.

As second case of comparison we have the work Evaluation of Renal Transplant Status using Viscoelastic Response Ultrasound [26]. The aim is to carry out an exhaustive and precise monitoring that evaluates the state of the renal transplant by means of ultrasound that can give a viscoelastic response. As it is known an alternative relevant biopsy could be an imaging technique that exploits viscoelastic properties of the tissue since kidney disease and can result in altered viscoelastic relationships between the pelvis and parenchyma. For this purpose, a delineation of the tissue was performed by VisR, allowing to distinguish non-invasive forms of biopsied and non-biopsied grafts and with the help of an image based on the acoustic radioactive force (ARF), allow to adjust the displacements showing us the process.

In comparison with the two articles already mentioned, the present project has a similarity with them both as a system is designed to look for similarities between two results obtained from analysis, only differing in the Methodology and the scope.

The project "Promoting and Assisting Eye Donations Using Mobile Application" [27], the project is based on the use of SQL Lite, which provides software to help find eye banks, has custom filters (name, address, GPS location) to locate the nearest eye banks and thus provide the contact information needed to make a donation. In addition, it makes use of SQL Lite in order to work with a fairly lightweight database.

The aforementioned project and the current project are similar in terms of objectives, both seeking to contribute to issues related to organ donation, and the differences found lie in the organ intended for donation and the platform to which it is directed.

Another similar project is "Kidney Transplant Classification with Gene Expression Profiles using LI Feature Selection Ensemble Classifier based on Data Clustering" [20]. The aim is to be able to classify patients' kidneys much more precisely, applying data grouping and classification techniques to obtain much more accurate results.

This project is focused on the analysis of data to classify and group; on the other hand, our project is designed to function as a registration and donor-patient matching system by the previous collected data available from the different health facility across the country.

4.2 About the Methodology

We propose an analysis of two articles, mentioning their methodology or procedures. As a first comparison we have the Computerized Decision Support System for paired kidney donation, the paper raises a strategy called paired kidney donation program (KPD) this is represented by a network of links formed by nodes, i.e. there are a certain number of nodes that are linked, these nodes represent an incompatible donor-recipient pair or an altruistic donor, each link from a starting node to another recipient node denotes ABO blood type compatibility and HLA sensitization each link associated with a link probability π indicates that the possibility of a successful kidney transplant from the starting nod to the recipient node. It also mentions how its algorithm will work, based on data input, database generation, graph generation, pc server for decision making and output results [25].

The following comparison is Classification of kidney transplant with gene Expression profiles using LI feature selection Set classifier based on data pooling, the methodology used in this research is classified in three phases as the first phase pose feature selection this phase is a filtering of the genes of normalization i.e. select genes based on their information to classify them, the second phase proposes Grouping which means grouping to determine the label of each gene, and by last phase mentions the Classification here is mentioned to make a cross validation of omission to divide the training data mentioned in the second phase and test, based on this is made prediction of new data or test to obtain a subset of measures [26].

As a first analysis, the team determined that each paper expresses an idea as to the steps that will be used for the realization of its applicationand we support the way in which they process the methods already mentioned above, besides that, no specific methodology is applied to be based and supported on it. In comparison with our methodology, we use Design Thinking, which is divided into 5 stages, which has been followed step by step for the realization of the paper. The second analysis is the way they try to implement their research in the society we consider that they are innovative ideas some with software applications and other with advanced technology, as far as it is concerned we can appreciate the symmetry with ours because in the other papers they use a test phase with volunteers for the analysis of the implementation of the paper.

5. CONCLUSIONS

In this work, the prototype of a web application was designed by collecting the data needed to perform the application of the

case study. The analysis of data collected from both the patient and the donor was followed by the development of ideas and the selection of the most appropriate approach, thus generating the basis for the development of the prototype of the web application, which measured the effectiveness and efficiency through specific questions, helping patients to achieve a better solution to the traditional situations of finding donors in a late time. This application allows reducing the time to find a donor compared to the traditional method.

The method applied was the most logicalas we looked for innovative models that improve, accelerate and visualize each process. For this reason, BalsamiqMockups tool has been used and helped in the contribution of the design and defining sketches respectively, as applying each phase of the methodology, ensuring that the development is done optimally.

In future research, it is recommended to have a database from a health center to validate the data or have a design to serve as a reference for how the prototyping would be developed and how the logic of each process would be in order to contemplate its correct functioning in the facility.

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