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Development of software for cost analysis of the process of captur organs and tissues for transplants

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ABSTRACT

Objective: Describe the development of software for cost analysis of the process of capturing organs and tissues for transplants. **Methods:** Descriptive and exploratory study of the development of an information technology tool based on the systems development lifecycle theory, through incremental process and prototyping models. **Results:** A digital tool was developed to collect clinical/epidemiological information and costs of potential organ and tissue donors for transplants, in English and Portuguese. **Final Considerations:** The developed software will be able to optimize and reduce the time of collecting cost information from potential organ and tissue donors, as well as providing quality information with less data inconsistencies, in addition to filling gaps on the real cost of conducting this strategy to public coffers.

Keywords: Costs and Cost Analysis; Transplantation; Tissue and Organ Procurement; Software; Technology;

INTRODUCTION

Transplantation consists of the replacement of organs, tissues or cells from a donor to a sick individual, called the recipient (Brazil, 2021). When it comes to obtaining organs, there are two types of donors: living and deceased (Boehm, 2020).

In relation to deceased organ and tissue donors, 13,195 potential donors were notified in Brazil in 2022, with 3,528 of these becoming effective. Regarding the causes of refusals to donate, family refusal comprised 3,523 cases (46%); cardiorespiratory arrest (CRA) before the brain death (BD) assessment protocol was finalized occurred in 952 cases; there was a medical contraindication to donation in 2,322 cases and other causes in 2,847 situations (Brazilian Organ Transplant Association, 2022).

In Brazil, the Ministry of Health, through the National Transplant System (Brazil, 2017), funds the process from the search for a potential donor to post-transplant monitoring. There are financial transfers through the Strategic Actions and Compensation Fund (FAEC) and the Financial Increase through the Quality Program in the Donation and Transplant Process (QUALIDOT), which, based on indicators of procedures related to solid organ and bone marrow transplants, treatment of post-transplant complications and pre- and post-transplant monitoring, can grant monetary incentives ranging from 40 to 80% (Brazil, 2022).

The amounts paid to hospitals that procure organs and tissues and carry out transplantation are fixed. According to the FAEC table, for example, R$ 215.00 reais is paid for the clinical assessment of the potential donor; R$ 600.00 reais for an imaging test to confirm BD; R$ 15.00 reais for blood typing; the daily rate in an Intensive Care Unit (ICU) is R$ 508.23 reais; and R$ 900.00 reais for the hemodynamic maintenance of the potential donor and the room fee for organ removal (Brazil, 2020).

However, when it comes to measuring the amount of resources used, there are not many national or international studies that survey/analyze the real costs, rather than the fixed tabular costs, spent during the process of assisting potential organ and tissue donors; nor are there any studies that estimate the cost of the various open protocols for obtaining organs when there is family refusal, CRA, medical contraindication or other impeding factors (Silva et al., 2022).

Real cost analysis in healthcare involves recognizing, quantifying and assigning values to all the resources used in healthcare. Thus, the cost of an activity, procedure or

therapy consists of the sum of the financial investment of all the organizational resources consumed to perform it (Drummond et al., 2015).

Thus, considering the importance of economic models in research to propose aspects that can improve the distribution of financial resources between government programs, as well as to evaluate how much the implementation of a strategy has cost the public coffers, to support the decision-making of health managers and professionals, the need to create a computer program that can guarantee quality and security in the collection, storage and constitution of systematized databases was verified.

To this end, software was developed for cost analysis of the process of organ and tissue procurement for transplants, which could be used in the future by transplant services to collect, organize and store data specific to the costing of this process. The aim of this study is to describe the development of a software program called "MAF_Cust_Transp".

METHODS

Ethical aspects

Research project approved by the Research Ethics Committee of the Federal University of Mato Grosso do Sul (UFMS) under substantiated opinion no. 5.381.784 and CAAE no. 50810121.5.0000.0021.

The production of the software also took care to respect Law No. 13,709 of August 14, 2018, on data protection (Brazil, 2018). To this end, the developers and researchers have created strategies that allow for the protection and security of personal and sensitive data handled in the program, to guarantee privacy as well as consent management, from an ethical and responsible perspective.

Design, location and period

This is a descriptive and exploratory study of the methodological development of an information technology tool, entitled MAF_Cust_Transp, during the period August 2021 and January 2023. The project and its implementation took place in the laboratories of the practice center at the Federal University of Mato Grosso do Sul and remotely using the Google Meet application.

Development process

At the beginning of each semester, the software engineering course at UFMS publishes a public notice to select proposals for the development of software artifacts by the Center for Software Engineering Practices at the Faculty of Computing. As a result, the researchers found that there was no cost computer program specifically designed to find out the real cost of potential organ and tissue donors, rather than the usual practice of transferring values by the Ministry of Health, and applied for call for proposals no. 24 of July 21, 2021, call for proposals no. 38 of November 5, 2021, and call for proposals no. 16 of April 25, 2022.

The construction of the software was based on the systems development life cycle theory (Pressman; Maxim, 2021), which consists of the skeleton of processes, activities and tasks necessary for the development, implementation and maintenance of the product throughout its life cycle.

To this end, a meeting was held between the team selected to develop the software and the team of researchers who requested its construction. At the first group meeting, given the complexity of the program requested, it was found that it would not be possible to produce all the software in one semester, so it was necessary to build it in stages and in complementary modules to complete the proposal.

For this reason, the incremental process model was adopted, which surveys customer needs and from this determines the most important functionalities and the necessary requirements to establish the delivery modules in order of customer priority. The prototyping model was also used to provide researchers with the system's functionalities throughout its development and testing of the requirements developed to better understand the functionalities, concepts and requirements necessary for its implementation (Sommerville, 2019).

Progressively, a series of modules and prototype versions, called increments, were provided as the set of functionalities was built (Pressman; Maxim, 2021). The first increments brought functional versions of the program to meet the basic requirements requested. Based on their use and/or evaluation, additional functionalities and applications were planned and developed.

Software development, according to the technology life cycle theory, took place in 5 stages: (i) communication between developer and client; (ii) planning, (iii) modeling (iv) implementation (building the source code) and (v) product delivery (Pressman; Maxim, 2021).

The Communication and Planning stage involved the development team and the program proponents to understand the expected functions, characteristics and requirements of the product to be developed. In addition, the resources and techniques to be used in the development process were defined.

The first goal was therefore to provide clinical/epidemiological data and costs for the tests carried out on potential organ and tissue donors. In the second stage, it was decided to implement the function of individual costs of the potential organ donor with medicines and hospital supplies and in the third stage to include all the other direct and indirect costs that were missing to complete the software.

The development of this software fulfills one of the objectives of an ongoing doctoral research project. Thus, the epidemiological and cost data requirements listed were extracted from field research in the medical records of potential organ and tissue donors who died in 2019, in the guidelines for the maintenance of multiple organs in the potential donor (Westphal et al., 2011); guidelines for the evaluation and validation of the potential donor in brain death (Westphal et al., 2016) and Brazilian guidelines for the management of potential organ donors in brain death (Westphal et al., 2021).

Modeling consisted of the stage in which the product's creators tested the models to understand the users' needs and defined the rules for the development process. Thus, considering that MAF_Cust_Transp will be used by more than one researcher and at the end of all the construction will be made available to transplant services, a structure was modeled for online access, free of charge and hosted on the free GitHub platform, which will allow access from various machines, if they are connected to the internet.

Next came implementation, transforming the models into a programming language and testing to detect possible coding errors. The programming language selected was Javascript. This was because Javascript can be run on any machine, and because it reduces server load and network congestion. In addition, the language can perform logical operations efficiently, which makes it easier to find and process complex information (Oliveira; Zanetti, 2020).

For the code repository and versioning control, GitHub was used, which consists of a cloud service that hosts source code and files, called Git, which allows developers to run projects in a shared way while keeping a detailed record of their progress. This allows for updates, corrections and other adjustments throughout the software's life cycle without the code base being lost (Bell; Beer, 2015).

Figma was used as a tool for prototyping and creating templates and content. Figma is a design tool that allows collaborative work between the team to improve the accessibility of the system (Wyse, 2022).

The database management system used was PostgreSQL, which is responsible for storing and retrieving data from the system. This system was selected because it allows data to be sorted and stored securely, as well as allowing data to be restored whenever necessary (Postgresql Global Development Group, 2023).

To finalize the construction of all the software modules and validate the functions of the Programs, tests were carried out on each of the units developed to check that the source code had been implemented correctly.

The product was delivered in three stages, in December 2021, June 2022 and January 2023, after the researchers had been built and trained to use the virtual tool.

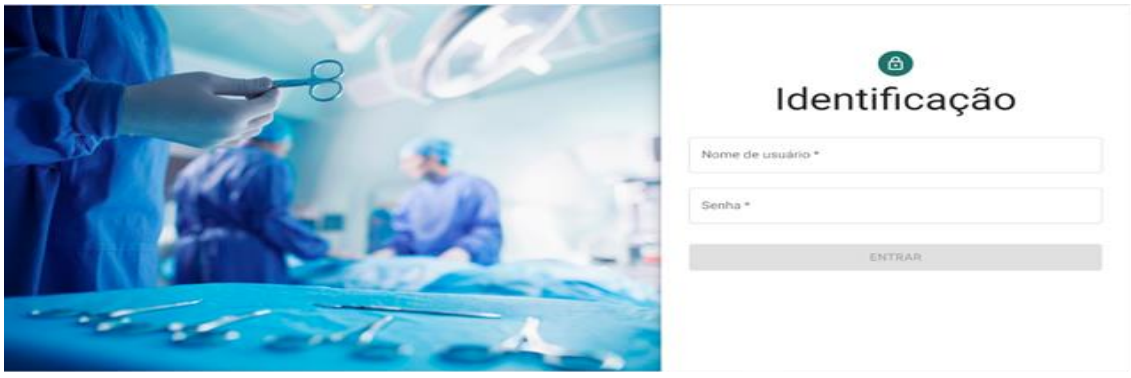
Computer program registration

The software was registered with the National Institute of Industrial Property (INPI), and had favorable opinions issued on December 23, 2021, under number BR512021003079-6, on August 2, 2022 under number BR 512022002003-3 and on January 17, 2023 under number BR512023000090-6.

RESULTS

The MAF_Cust_Transp Program, a digital tool for clinical/epidemiological and cost information on potential organ and tissue donors for transplants, has been finalized and the process of making it available online is underway. The program works in Portuguese and English. Figure 1 shows the system start-up screen:

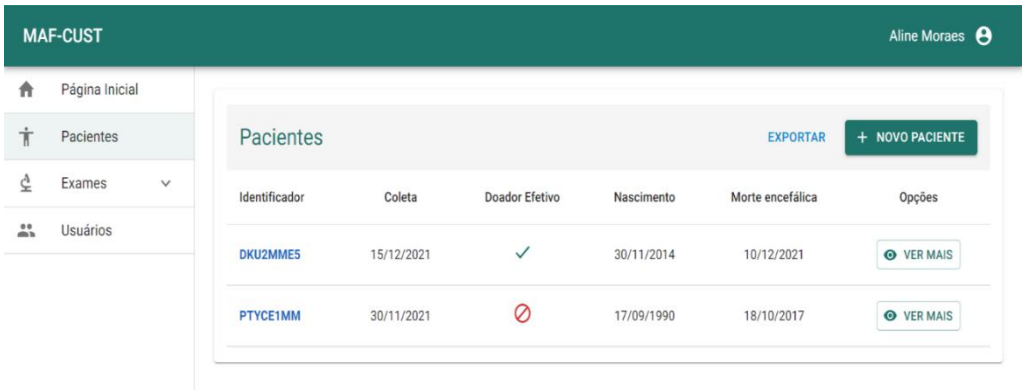
Figure 1 - Initial identification screen to access the system.



As can be seen in figure 1, the system presents an initial screen so that registered users can authenticate using a login and password. Once logged in, the main screen shows the following options: patient, exams, materials for individual use, laundry costs, water, electricity, telephone, human resources, reports and user permission control.

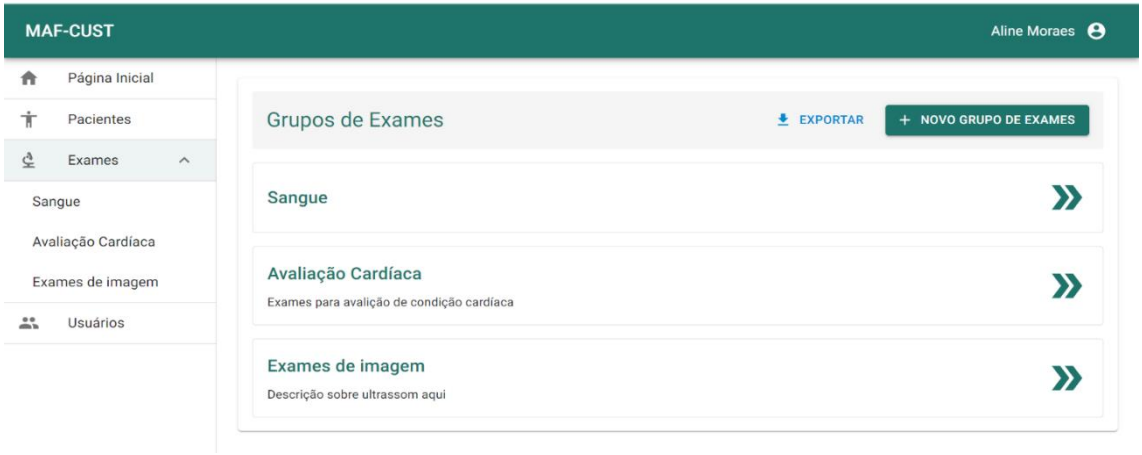
In the patient option, it is possible to register a new patient or check/evaluate/edit information about those already in the system. To avoid identifying the patient and exposing data, the system automatically creates an identification code when you enter a new individual, made up of letters and numbers (Figure 2).

Figure 2 - Identifier generated by the system.



You can then register all the tests carried out by the patient, the number of times and the individual value for each test, as well as all the medicines and hospital supplies. The system allows you to add new tests and supplies and edit values, if necessary, for all the items in the program. The values will be added by the individual using the system, according to the price system in their region, which is why the option to edit values is essential (Figure 3). In this system it is also possible to export data in spreadsheet format to the external Microsoft Excel® tool and to the Adobe Acrobat Reader® PDF tool, to reduce the risk of errors when transcribing data.

Figure 3 - Exam registration screen



The program allows the reports on the total costs of potential organ and tissue donors, as well as the costs separated into the actual donor and non-organ donor categories. The tool allows you to edit the number of times the tests were carried out, as well as the unit cost, in addition to automatically providing the subtotal and final value of the costs. The report also shows the actual donor's statement in relation to the number of organs donated and the total value of the purchase of these organs.

About the care taken with sensitive identification data provided for in general data protection legislation, the program encrypts it to guarantee its security and legality before it is stored in the database. In addition, a request and authorization via email, generated in the system itself, is required for family members of potential organ donors or for the institution where organ procurement was attempted.

In the first case, after contacting the family member, they are asked to sign an informed consent form. The researcher then requires a valid email address and contacts them with a request for authorization to use the data in MAF_Cust_Transp.

The second case applies when the institution has already included in its informed consent form, for hospitalization, the presence of documents and signatures from family members that allow the use of hospitalization data for research or database construction.

The MAF_Custo_Transp system allows retrospective extraction of data available in existing medical records, if you have a computer connected to the internet. The data is fed into a database installed directly on the computer used. In addition, the program is multiplatform, meaning it can be used on computers running Windows®, Linux® or MacOS® operating systems.

DISCUSSION

In absolute numbers, Brazil is the second largest transplanting country in the world, behind only the United States of America (USA). Approximately 96% of procedures are carried out by the SUS, making Brazil the largest public transplant system in the world. Patients receive all the preparation for the transplant and post-procedure follow-up through the public health network (Brazil, 2021).

The Brazilian health system is characterized as universal, that is, rights are universal, funding comes from taxes and management is public. In this scenario, Brazil, like other countries around the world, has faced the challenge of sustaining the health system, in which health spending has often grown at rates higher than the gross domestic product (GDP). In Brazil, total spending on health corresponds to 9.1% of GDP (Conass, 2018).

Current spending on transplants is around R$1.3 billion, which includes the cost of surgery and immunosuppressive drugs for post-transplantation (Brazil, 2018). The federal government invests around R$160 billion in the SUS, and the states around R$170 billion, which means that the amount allocated to transplants does not correspond to 1% of public resources. Another factor worth mentioning is that the last readjustment in the package of fixed amounts passed on to institutions that collect organs and tissues and carry out transplantation took place in May 2012 (Glock, 2020).

Costs are understood as the economic measurement of resources, whether they are products, services and/or rights in a company, paid for some good or service provided or acquired. Thus, the cost of an activity, procedure or therapy consists of the sum of the financial investment of all the organizational resources consumed to carry it out (Chen, 2022).

Healthcare costs are classified as direct, indirect and intangible. Direct costs include all the resources used during the health procedure or intervention, such as hospital fees, health team fees, medicines, diagnostic and complementary tests, procedures, medicines, transportation, among others (Fautrel et al., 2020).

Indirect costs refer to the consequences of illness or general operating costs, known as overheads, such as water, electricity, cleaning, maintenance, administrative staff costs, building and equipment depreciation (Brazil, 2019). Intangible costs are the

most difficult to measure, as they reflect changes in the individual's quality of life (Silva; Silva; Pereira, 2016). The software developed took direct and indirect costs into account.

In several countries, economic studies have been carried out for years as an attempt to improve health systems for efficiency, expansion of supply and new technologies, in a safe and effective way, with the adoption of monitoring and evaluations derived from health economics. In Brazil, however, some challenges still need to be faced, due to the lack of tradition, installed capacity and the need for more research in health evaluation, specifically costs (Ribeiro et al., 2016).

In relation to the field of transplants, the management of every potential organ and tissue donor requires manpower and technology, invasive monitoring; pharmacological support and frequent laboratory tests to assess the effectiveness of the therapy. In this respect, the scientific literature is emphatic in stating that transplantation is a costly process for both public systems and third-party payers (Giordani et al., 2020).

This highlights the need to standardize the process of collecting cost data in order to improve the efficiency of the process and generate robust, timely and efficient evidence to support decision-making (Jacobsen; Boyers; Avenell, 2020).

Considering that health costs have grown exponentially and that decision-makers are concerned about this issue in a scenario of finite health budgets, information technologies represent a promising alternative for reducing costs and expanding and improving health services (Uziel, 2020).

In this direction, information technologies such as programs that collect cost data become important. This software, which enables cost analysis of the process of organ and tissue procurement for transplants, is part of a doctoral thesis and will serve as the basis for testing and validating the MAF_Cust_Transp system.

There is therefore a need to awaken interest in the development of new technologies, such as programs and applications designed for the practice of collecting data for research, treatment and support for health professionals and patients. This vast field still needs investment, new studies and innovative practices (Kannan; Hongshuang, 2017).

The main limitation of this research was the need for further tests to adjust and optimize the program.

FINAL CONSIDERATIONS

In a scenario of limited financial resources, it is essential to use information technology in the economic evaluation of activities carried out in the health area, specifically in the procurement of organs and tissues, to identify, measure, evaluate and compare costs. This tool will make it possible to fill in gaps in the real cost of carrying out this strategy to the public purse, which could have repercussions in terms of better distribution of financial resources and support decision-making by health managers and professionals in their practices.

It will provide health professionals with a management tool that can be used by organ and tissue procurement services for transplants, producing cost indicators to optimize the donation-transplantation process. In the same way, all the professionals involved will benefit, as will the patients, since better allocation of resources based on costs could optimize the number of procedures and reduce waiting times in transplant queues.

Similarly, specific public health policies for this patient population could be improved in the quest to serve a greater number of people, with improvements in the services provided to them.

Understanding the costs of obtaining organs and tissues can shed light on areas in which obtaining effective donors can be improved in terms of cost and efficiency. Deprecating costs using computer programs will make it possible to optimize and reduce the time it takes to collect information, as well as providing quality information with fewer data inconsistencies

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