Analysis of the Organ Donation and Transplant Process with Process Mining: Comparing 2021 and 2022 Supply Chain Data in Rio de Janeiro

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Abstract

The organ donation and transplantation supply chain - ODTSC is a complex and multi-professional system with donors, organs, recipients, and waiting families on the upstream chain side and transplanted patients, and their families, on the supply chain downstream side. Health professionals must coordinate and streamline the donation, transplantation, and transplanted patients' care, as the 3 main processes in the ODTSC. These processes have been improving in several countries, but the global demand for donated organs is nearly 1,3 to 2 million and the transplantation capacity is below 150,000 surgeries. The research was motivated by low performance when comparing Rio de Janeiro data from 2021 and 2022 to benchmarks and its main objective was to improve practices by analyzing the ODTSC and its process and data. Process mining - PM has been evolving from a process and data science topic to a useful technology related to production engineering. In health services, the hospital environment, health production systems, and society benefit from PM utilization with a new way to increase value. Discover the variants, checking the conformance to regulations, analyzing causes, and proposing improvements are PM techniques used to enhance performance and reduce the gap between organ demand and supply. The data was used to analyze the process design, the data itself, and indicators by applying PM techniques and using a tool. The methodology was based on the design research and multiple studies cases methods with a bibliographical review - and no previous work was found, demonstrating the novelty of this research; PM tools selection, data preparation; and interviews to identify improvements. With the study, it was possible to demonstrate the applicability of PM, and an increase of 15 % in organs donated in Rio de Janeiro ODTSC was observed.

Keywords
Process, management, organ, data analysis, transplantation, mining

1. Introduction

For many years, the worldwide demand for transplants has remained higher than the capacity of health systems to deliver organs. The global demand for organs and transplants was studied by Matesanz et al. (2017) and by Global Observatory on Donation and Transplantation (GODT 2016). Both research estimate that about 1.3 and 2 million people need a transplant in the world, while only 140,964 organ transplants occurred in 2018 worldwide (GODT 2019). These statistics demonstrated an important and huge gap between supply and demand. The scenario worsened with the Covid19 pandemic, decreasing the number of organ transplants between 2020 and 2022 by 16% due to the pandemic restrictions and virus contamination (GODT 2022). According to Kute et al. (2021), there was a disproportionate impact of COVID-19 on different areas of the world and globally, there was a decline of 17.5% in deceased donations. The impact was even more significant in Brazil, with 29 % fewer organs effectively donated in that period (Garcia et al. 2022).

However, it is undeniable the efforts countries have made to increase the number of donors and to reduce the gap between demand and supply of organs. In the United States, for example, the American Society of Transplant Surgeons (ASTS) envisioned ending organ shortages by increasing post-mortem donations, living donations, and better utilization of organs (Hobeika et al. 2017). It is paramount to face ODTSC challenges and it equally important to improve its performance.

Matesanz et al. (2009) and Páez et al. (2013) report the scarcity of donors as one of the reasons for the disproportion previously mentioned. However, several authors argued that the number of transplants would significantly increase if we eliminated the inefficiencies in the organ donation supply chain and process. In this regard, different authors worldwide and in Brazil report that the loss of organs occurs throughout the entire process, from identifying donors to problems during the transplant surgery (Matesanz and Domínguez-Gil 2007; Shanmugarajah et al. 2014; Rosendale et al. 2011; Hoste et al. 2016; Matesanz et al. 2017; Hobeika et al. 2017; Duran 2017; Arora and Subramanian 2019; Paim and Figueiredo 2019; Mota et al. 2020; Soares et al. 2020; Lewis et al. 2020; Cole 2021; Silva et al. 2021; Marinho and Araujo 2021; ABTO 2023). In this context, the organ donation and transplantation supply chain and its processes (ODTP) can be improved if applying the Industrial or Production Engineering and Operations Management body of knowledge (Howard 2007; Arora and Subramanian 2019).

Process mining (PM) is an area of knowledge that has grown in the scope of topics related to production management and process and data management. PM techniques - like discovering, conformance checking to regulations, procedures, improvements, and best practices, among others - demonstrate how data can improve the organ supply chain and process. PM has shown promising results, especially in the business and public environment, with particular emphasis on health services. The hospital environment, the whole logistics health production system, and society are beneficiaries of the PM tools and techniques adoption and application. PM has potential in healthcare although there a room for more research in the field (De Roock 2022). Therefore, applying PM techniques to the ODTSC and processes can help face the challenge of improving the number of organs available for donation. Moreover, to the best of our knowledge, there are no previous articles relating to ODTP nor ODTSC and process mining. The authors searched several databases (e.g., Scopus), employing the terms "organ or transplantation or donation" and "process mining", and “process” or “supply chain” and there was no return, indicating that this is the first study applying PM to manage and improve the ODTP or ODTSC. This emphasizes the novelty of this research as no previous work or studies were found on this specific topic, demonstrating the originality of the research and its contribution to the field. In Brazil, the shortage of organs is a significant problem. According to the Brazilian Transplantation Registry (Registro Brasileiro de Transplantes – RBT) data, published by the Brazilian Organ Transplantation Association (ABTO 2023), Brazil has almost 53 thousand (52.989) people on the waiting list, and its 27 federal units together are reaching 1.5 pmp donors.

Brazil also performed, in absolute numbers, the 4th (after being in 2nd for many years) largest number of transplants in the world (13.979). Despite that, relative to its population, the country occupies only the 24th position in the number of effective donors and the 32nd in the number of transplants performed. According to RBT, if Brazil reduced the number of losses in identifying possible donors, transforming these patients into effective donors, and increasing the utilization of their organs, these indicators would be much more favorable to the country (ABTO 2022; ABTO 2023). The RBT published in 2022 demonstrated that the number of transplants was 7,405, in 2021 and 8,021, in 2022, an 8.3% increase. When comparing 2022 to 2021, there was a 10 % increase in effective donors (3,207 in 2021; 3,528 in 2022). In addition to this problem, in Brazil, the COVID-19 pandemic impacted the ODTSC and process directedly, mainly because during 2020 and 2021, the potential donor with COVID-19 was an absolute exclusion criterion.
More than 90% of the transplants in Brazil are financed with public resources. Rio de Janeiro has several specificities, for example having Federal, State, and Municipal public hospitals as well as having private hospitals with or without

contracts with the government to allocate funds. This increases the complexity of managing organ donation and transplantation resources and performance.

Given the above, it is necessary that the ODTP and ODTPSC become more effective and capable of bringing more quality of life and hope to patients waiting for organ transplantation due to a terminal illness. Rojas et al. (2016) state that the PM application has significant positive aspects in identifying activities restricting the process, the improvements proposition, and the waiting line analysis. Those aspects can improve performance, healthcare service, and ODT management.

2 Objectives and Paper Structure

In this context, this study intends to analyze the organ donation and transplantation process. The method focused on comparing data from 2021 and 2022 in Rio de Janeiro state. The major aim was to discover new ways to benefit Brazilian society, using improvement and managerial practices and technologies. To reach this objective, an analysis of the process design, data modeling, and performance indicators was carried out. The ODTSC and process data were analyzed with the application of PM techniques, using a tool, and the construction of process data visualizations took place. In addition, the study gathered and proposed improvements for the discovered process. The object of study was the whole donation process of the state of Rio de Janeiro, with data collected and recorded during 2021 and 2022, and comparing hospitals, CIHDOTT (Donation and transplantation committees inside the hospital), and OPO (Organ Procurement Organization).

This paper is organized as follows. The previous section was introductory. This section presented objectives and show the paper's structure. Section 3 presents the background of organ donation and transplantation relating it to the supply chain, process, and data concepts and intents to illustrate the context. Section 4 presents the research methods. Section 5 expresses the results and some processes and data revealing the PM techniques application and impacts on the ODTSC and process. Section 6 proposes a general discussion. Finally, section 7 closes the paper with the conclusions.

3 Literature Review

3.1 The organ donation and transplantation (ODT) supply chain and process

Mota et al. (2020) studied the ODTSC investigating the process of donation, the retrieval of organs, and the transplantation itself using engineering methods based on logistics analyses. The authors argue that applying supply chain concepts is a complex technical effort of medicine. According to Lambert et al. (1998), “Supply Chain Management (SCM) is the integration of key business processes from end user through original suppliers that provides products, services, and information that add value for customers and other stakeholders”. This study considers the supply chain of the healthcare industry as different from the manufacturing sector in terms of the level of customization of services provided, the participation of partners or consumers or patients and the uncertainty underlying the process. Healthcare supply chain therefore is unique and different from other industries. It is a complex network consisting of many different parties at various stages of the value chain (Mathew 2013).

The supply chain concept demands a mathematical layer of engineering to build a multidisciplinary approach to a complex problem: how to notify, evaluate, extract, transport, and implant an organ in no more than, in liver cases, 12 hours, and heart organs in no more than 4 to 6 hours. Mota et al. (2020) add the multimodality challenge - jointing the use of helicopters, airplanes, and emergency vehicles - for optimization models, investigated by engineers, mathematicians, and computer scientists, working with a health professional. To these Brazilian authors, ODT Supply Chain is a fertile field to deploy years of studies with an uncommon but highly relevant objective - saving lives. Barreto et al. (2020) highlight the teams' multidisciplinary and logistical preparation to ensure the donation's success. Lewis et al. (2020) describe the US and European Organ Donation imbalance between supply and demand for transplantation. These authors present strategies to address the organ shortage: increasing the potential donor pool, increasing consent rates, increasing efficiency in organ allocation, and decreasing the demand for transplantation with better health primary care. Cole (2021) states that in response to supply and demand inequalities and organ shortage, the healthcare industry is developing systems that smooth and accelerate the procurement and delivery of organs, creating a standardized, data-driven logistical network. Nevertheless, the author criticizes how these supply chain practices are being applied and raise the risk of creating inequalities in organ allocation.

In simple terms, the ODT process can be understood as the set of actions taken to make organs available to be utilized in transplants. Transplantation is a surgical technique in which organs and/or tissues are removed from one organism and implanted in another (Oliveira 1997). The donation is the first of the three phases of the transplant, including the implant itself and the transplant patient's follow-up (Gussen 2014). Fuzzati (2005) divides the transplant process into organ retrieval and implant surgery. Finally, Hoste et al. (2016) studied the literature about the process, such as care pathways for organ donation after brain death (BD).

According to Mota et al. (2020), the ODTP adds value in a major supply chain context. These authors studied the São Paulo state liver supply chain, and Cole (2021), as mentioned, raised the risks in managing the organ donation supply chain. Considering these previous works, the donation and transplantation were understood as a process, with activities sequenced and with interactions encompassing several entities and people, and that results in the transformation of a possible donor into an effective and authorized donor, with one or more transplanted organs to increase and improve the quality of life of those on the waiting list (Fuzzati 2005; Howard 2007; Cole 2021; Domínguez- Gil 2011; Hoste et al. 2016; Garcia et al. 2017; Garcia et al. 2019; Garcia et al. 2022).

The World Health Organization (WHO) recommends the standardization of nomenclatures, and according to Garcia et al.(2022), a possible donor is a person with severe brain injury on mechanical ventilation; Potential donor is defined when an evaluation with a BD protocol is opened or started for the person; Eligible donor, when the diagnosis of BD is confirmed; and Effective donor, when the organ is used, due to retrieval surgery (or removal) and transplant surgery (implant) with the utilization of the donor's organs.

In Brazil, in cases of deceased donors, it is necessary to have a confirmed diagnosis of BD, the organs to be transplanted must be functioning, there must be family authorization to proceed with the procedure, and finally, there is a need for express formal consent from the donor family (Soares et al. 2020).

In order to understand the opportunities for improving the ODT process, the activities of the donation process flow must be detailed. This study took into consideration previous works which detail the ODTP, Garcia et al. (2022), Silva et al. (2021), Guerra et al. (2002) and Pestana et al. (2013). According to the literature reviewed, the sequence of activities in the ODT process is: identification of possible donors and detection of admitted patients in the hospital, notify potential donors, evaluation of potential donors, diagnosis of possible BD, evaluate brain death BD, validation of donation cases with eligible donors or exclude organ donation, conduct the family interview and communication, family consent to organ donation, rank recipient patients and allocate organs, perform organ clamping in actual donor; organs retrieval surgery, transplantation, and follow-up after transplantation of patients. In addition to these steps, the maintenance of the potential donor also occurs, in parallel, until the donor enters the surgical center.

Therefore, the ODTP is complex, with many obstacles contributing to the increased waiting list for transplants. The main problems are underreporting of BD, lack of knowledge about the concept of BD by family members as well the lack of competencies to provide information to support family decisions, lack of credibility in this service, medical contraindications, logistical difficulties in maintaining the potential donor, delay in detecting BD, and lack of family consent (Matesanz and Miranda 2002; Matesanz and Domínguez-Gil 2007; Domínguez- Gil 2011; Knihs 2011; Hoste et al. 2016; Hobeika el al. 2017). In Brazil, Paim and Figueiredo (2019) have used Lean concepts to identify significant losses in ODTP as under notification of BD, family refusal, and low utilization of organs from the same donor. The last one adds complexity due to the transportation logistics of multiple organs, retrieval teams, transplant teams, materials, hospitals, families, exams, and recipient's patients.

3.2 Process Mining

PM has emerged as an alternative or complement for process improvement to fill a gap between Data Mining (DM) and Business Process Management (BPM) (Garcia, et al. 2019). For a better understanding of the definition presented, it is understood that Data Mining is a technique based on methods focused on Big Data processing, that is, a technology dedicated to data processing for the delivery of reports or dashboards (Sedkaoui 2018).

Also, it is understood that BPM is based on a structured and systematic approach to the continuous analysis of processes (Paim, et al. 2008). Van der Aalst (2012) defines PM as a research area that combines process modeling techniques, data mining, model-based analysis, and machine learning.

The goal of PM is also to offer a new way of modeling processes without spending too much time on manual analysis. For this, it is intended to extract knowledge from a process model based on data and events that were recorded in an information system, that is, information collected during the actual execution of the process.
The starting point for the application of PM is the event log, understood as a set of data referring to a process. For van der Aalst (2008), an event log must meet the following requirements: refer to a process activity, refer to a case, and be orderly, as demonstrated in Figure 1. Another basic element, not mandatory, for the application of PM, is the construction of a table that contains data that can characterize, describe, and provide information about each specific case, which may vary according to the purpose of the analysis.

Case ID	Activity	Timestamp
1	Admit Patient in hospital	29/12/2020 00:00
1	Notify potential donor with possible Brain Death	01/01/2021 09:20
1	Evaluate brain death (BD) - 1st exam	31/12/2020 18:41
1	Evaluate brain death (BD) - Grafical exam	01/01/2021 09:20
1	Validate Donation case with Eligible Donor or exclude	01/01/2021 15:41
2	Admit Patient in hospital	19/12/2020 00:00
2	Notify potential donor with possible Brain Death	01/01/2021 10:20
2	Evaluate brain death (BD) - 1st exam	01/01/2021 09:20
2	Evaluate brain death (BD) - 2nd exam	01/01/2021 12:00
2	Evaluate brain death (BD) - Grafical exam	01/01/2021 14:20
2	Validate Donation case with Eligible Donor or exclude	01/01/2021 22:20
3	Admit Patient in hospital	25/12/2020 00:00
3	Notify potential donor with possible Brain Death	01/01/2021 16:50
3	Evaluate brain death (BD) - 1st exam	01/01/2021 14:38
3	Evaluate brain death (BD) - 2nd exam	01/01/2021 16:00

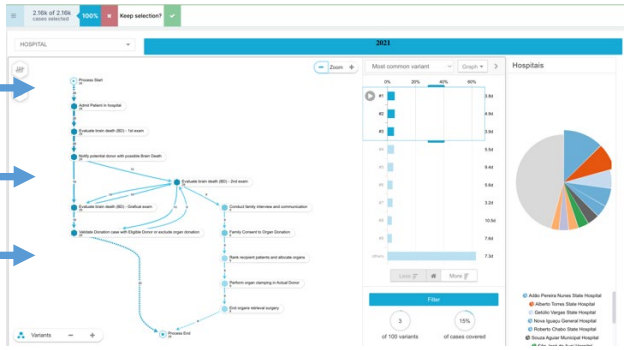

Figure 1. Event log converted to a discovered process with PM technique and tool.
The complete model available at https://bit.ly/comparing21_22

According to van der Aalst (2012), PM can be applied with three main techniques: discovery, conformity, and improvement or enhancement. The discovery uses the event log and produces a model of the real process, as it is being executed, thus allowing analyzing its variations. The second technique used is conformity or compliance, which consists of comparing the existing or ideal model of the process with the model created from the event logs of the same process. The third technique is enhancement, which consists of improving the existing process model using information obtained from the process recorded in the event log, to better reflect reality or to have an improved reality. Tiwari et al. (2008) presented trends more than a decade ago, and Loyola-González (2023) presents trends, a software comparison, and challenges in process mining nowadays and his study confirmed the potential of using PM.
Park et al. (2023) propose a method to extract, construct, and analyze event logs from the Common Data Models (CDM) using Electronic Health Records (EHR) for process types including inpatient, outpatient, emergency room processes, and patient journeys. The author states, to date, however, rare attempts exist to leverage CDM data for healthcare process mining.

Table 1. Key findings or main points from literature review studies

Concept or Theme	Author	Key finds or concepts
The organ donation and transplantation (ODT) supply chain and process gaps and problems	Mota et al. (2020); Gussen (2014); Fuzzati (2005)	Organ donation and transplantation Supply Chain - ODTSC Donation and transplantation process The donation is the first of the three phases of the transplant, including the implant itself and the transplant patient's follow-up transplant process can be divied into organ retrieval and implant surgery.
	Guerra et al. (2002); Fuzzati (2005); Howard (2007); Pestana et al. (2013); Cole (2021); Domínguez- Gil (2011); Hoste et al. (2016); Garcia et al. (2017); Garcia et al. (2019); Silva et al. (2021); Garcia et al. (2022)	Studied the literature about the ODT processes ODT subprocesses

Concept or Theme	Author	Key finds or concepts
	Lambert et al. (1998)	General Supply Chain concept
	Mathew (2013)	Organ Donation and Transplantation value chain
	Barreto et al. (2020)	Highlight logistical preparation to ensure the donation's success.
	Lewis et al. (2020)	Describe the US and European Organ Donation
	Cole (2021)	Criticizes how these supply chain practices are being applied and raise the risk of creating inequalities in organ allocation.
	Garcia et al.(2022)	Donors concepts and stages from possible, potential until donar with organs utilized.
	Matesanz and Miranda (2002); Matesanz and Domínguez-Gil (2007); Domínguez- Gil (2011); Knihs (2011); Hoste et al. (2016); Hobeika el al. (2017); Paim and Figueiredo (2019)	Challenges, problems and losses in ODTP and SC.
Process Mining	Garcia et al. (2019); Sedkaoui (2018); Paim, et al. (2008);	PM as a technique to fill the gap between Data Mining (DM) and Business Process Management (BPM); Big Data; BPM concepts and task;
	van der Aalst (2012); van der Aalst (2008); van der Aalst (2012);	Process mining concepts; PM research area that combines process modeling techniques, data mining, model-based analysis, and machine learning; PM three main techniques: discovery, conformity, and improvement or enhancement: PM event log requirements.
	Tiwari et al. (2008); Loyola-González (2023)	PM trends, software comparison, and challenges in process mining a decade ago and nowadays;
	Park et al. (2023)	method to extract, construct, and analyze event logs using Electronic Health Records (EHR).
Indicators of the organ donation process	Siqueira et al. (2016) Deulofeu et al. (2010) Carámbula et al. (2020) De Andrade and Figueiredo (2019) Araujo and Siqueira (2023)	Efficiency of the ODTP and ndicators of the donation-transplantation process can be grouped according to the different stages of the process; Indicators to assess the relevance and effectiveness of organ donation and transplant process; "New indicator*", "Organ Use Rate", an important measure to increase and improve efficiency in ODT. De Andrade has proposed this indicator previously. Impact of educational and organizational Initiatives on organ donation. The study considered a southern Brazilian state between 2009 and 2018; Educational initiatives shall be measured.
Data and Process Analytics	Arias et al. (2020) Sedkaoui (2018) Azvine (2006) Siqueira et al. (2016)	PM can facilitate the analysis of processes since it can perform the analysis through data stored in electronic health systems; PM increases the potential to obtain results. Methods help extract relationships between different sets of data and thus extract statistical information contained in the data in the most succinct way possible. Process analytics is utilized in a specialized manner in business intelligence ; The main objective of process analysis is to overcome the barrier encountered when organizations try to transform data into information and then into action.

3.3 Indicators of the organ donation process

According to Siqueira et al. (2016), the efficiency of the ODTP is indicated by the relationship between the number of organs offered, the inputs, and the number of outputs, such as the number of transplants performed and the survival rate. For the present study, a literature review was carried out to identify indicators of the ODTP, and some considerations can be made. Indicators of the donation-transplantation process can be grouped according to the different stages of the process (Siqueira et al. 2016). In addition, there are some indicators to assess the relevance and effectiveness of organ donation and transplant process (Deulofeu et al. 2010). In turn, Carámbula et al. (2020) proposed a new indicator, "Organ Use Rate", an important measure to increase and improve efficiency in ODT.
Considering the literature review, many available indicators applicable to the ODTP are known, but unfortunately, only a few are used to improve the process consistently in Brazil. Therefore, based on interviews with PET specialists from Rio de Janeiro and the state of Santa Catarina, a prioritization was made of which indicators would be used in the study, namely: characterization of donors by age group, race, blood type; cause of death; identification of BD in the state (pmp); rate of interviews carried out; rate of loss of donors during maintenance; rate of BD notifications/resulting effective donations; conversion rate from eligible donors to effective donors; effective donors in the state (pmp); family denial, non-authorization, or non-consent; percentage of absolute contraindication; percentage of medical contraindications; extraction or retrieval rate; organ utilization rate and organ utilization from the same donor. Some indicators may be proposed as, for example, De Andrade and Figueiredo (2019) evidenced the impact of educational and organizational Initiatives on organ donation. The study considered a southern Brazilian state between 2009 and 2018. Araujo and Siqueira (2023) also indicate that educational initiatives shall be measured.

3.4 Data and Process Analytics

PM is an area that performs process analysis based on data, using data analytics techniques. Arias et al. (2020) talk about how PM can facilitate the analysis of processes since it can perform the analysis through data stored in electronic health systems according to the routine of processes, increasing the potential to obtain results. This information is input for possible insights that improve clinical processes, being able to make changes such as changing the sequence of some tasks and obtaining improved results. One can, also, understand data analysis as a set of statistical methods that make it possible to process a significantly large volume of data and recognize the most interesting aspects of its structure. Some methods help extract relationships between different sets of data and thus extract statistical information contained in the data in the most succinct way possible (Sedkaoui 2018)

Process analytics is utilized in a specialized manner in business intelligence (Azvine 2006). It uses the same data as most other types of analysis but views it with traces of processes. The main objective of process analysis is to overcome the barrier encountered when organizations try to transform data into information and then into action, which is the manual process involved in collecting, analyzing, and disseminating or multiplying results (Siqueira et al. 2016).

4 Methods

The methodology was based on articulating design research and study case methods. Combining Lacerda et al. (2012) and Yin (2014), the research consisted of carrying out a literature review, searching PM tools, collecting, and sanitizing process data, creating data visualization, comparing data from 2021 and 2022, as well as building proposals for improvements with the interviewed health professionals involved in the process. The study framework is in Figure 2.

4.1 Research Design

The method was based on exploratory and descriptive research, with qualitative and quantitative analysis, grounded on design research science methods (Lacerda et. al 2012) and Yin (2014) was used to guide hospital case multiple case studies. The research was divided into six phases. In the first phase, a literature review took place, selecting and reading articles, books, and reports. This was an exploratory reading performed to find previous studies on organ donation, organ donation processes, and PM. Part of it used snowballing and used bibliographical review to identify relevant literature. The research problem was to discover if PM could be applied and improve Rio de Janeiro Organ Donation and Transplantation Supply Chain and the research questions formulated were: RQ1 – Is PM applicable to discover ODTP in ODTSC with the data recorded in Rio de Janeiro in 2021 and 2022? RQ2 – With the data available it will be possible to create useful ODTP and ODTSC indicators? RQ3 – Comparing ODTSC process and data it is possible to identify positive impact improvements? And this benefits Rio de Janeiro society with more ODT? Yin (2014) states there is no unique way of establishing completely objective criteria for such discoveries. Therefore, the authors of this paper assessed the findings and discussed the data collected.

4.2 Case and Tool Selections

Data analysis was divided into 2 parts, the 2nd and 3rd phases. During the second phase, the researchers interviewed professionals working in day-to-day organ donation activity in Rio de Janeiro. The intent was to acquire knowledge

about the real processes and understand how they work. The cases were selected basically because they had or had not records on ODT activities. 155 hospitals, 80 of them with CIHDOTT. These hospitals were managed with 5 OPO support, and all of them are coordinated by a central unit named CET, State Transplant Coordination Unit. No previous knowledge about supply chain, process, or mining was required for the hospital or unit to participate. All together and working in a synchronized way as the PET or State of Rio de Janeiro Transplant Program (Programa Estadual de Transplante acronym, in Portuguese).

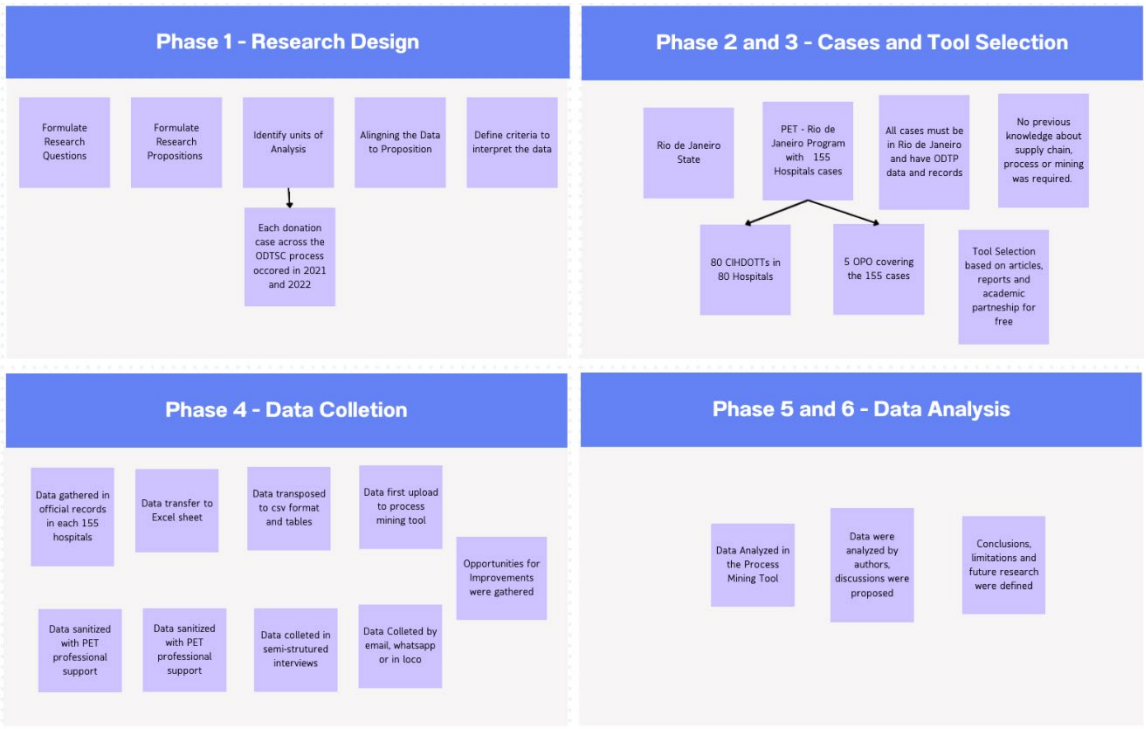

Figure 2. Research Method Framework

The third phase was dedicated to searching and selecting a PM tool to be utilized in the study. The string used in a search in 2020 and another in 2023 was “organ donation” and “process mining” and “data” and “supply chain”, in the last 10 years, peer-reviewed articles, in all areas, resulting in 42 articles in English and Spanish. After authors 1 and 2 applied the PRISMA technique only one article was selected and fully read. The snowballing found other two articles. Dogan (2021) applied Spherical Fuzzy AHP and Sensitivity Analysis to Selection Process Mining Technology. The study was published after this research started and the final rank considered Price, Process Discovery, Process Analysis & Analytics are the most relevant criteria and compared ABBYY, ARIS, Celonis, Lana, Minit, MyInvennio, PAFnow, ProDiscovery, Signavio, and UIPath. Dogan (2021) discovered Minit as the best tool and ProDiscovery using the AHP method and 8 criteria: Fit in the IT environment, Price, Providing research support, Process Discovery, Process Analysis & Analytics, Conformance Checking, Operational Support, and Enhancement Capabilities. Celonis and ProDiscovery are the worst in price criteria. Celonis tool was free to Cefet/RJ and to the present research, due to the academic alliance. Taking into consideration market studies, Everest Group (2020) considered the selected tool as the market leader in February 2020. Gartner (2023) nowadays considers Celonis at the best position in the quadrant utilized to compare tools. Loyola-González (2023), when comparing PM software, indicates Appian as the best option for process automation as low-code automation software. myInvenio, EverFlow, and Celonis were the best scores in the advanced enhancement category.

The author highlighted that Celonis has scored the best out of the remaining benchmarked 15 process mining software considering 55 features. In 2020, Celonis was selected because it was evaluated as the principal PM tool considering the studies found and the already cited Academic Alliance. According to the comparison between the ProM, Disco, Celonis, and MyInvenio tools carried out by Celik and Akçetin (2018), some characteristics about Celonis that are interesting for this study can be noticed, such as it has a good interface for use, accepts CSV and XLS formats for importing data, there are several formats to access the tool, and it is possible to have model notations in the form of graphics and dashboards. In the fourth phase, 2021 process data was gathered, sanitized, and modeled. The adjustment was performed with several iterative interviews with PET professionals. Nowadays, is it planned to use the same data adding 2023 data to test and Brazilian tool named Up Flux.

4.3 Data Collection

The data was gathered from hospitals by PET professionals and research team members in the 4th phase. Data was gathered in official records in every 155 hospitals. As mentioned, PET is a coordination unit accountable to manage the entire supply chain and process from donation to transplantation. PET helped provide data in Excel sheet format. The authors transposed data to CSV format and tabled it. Indicators were also defined from the literature and validated with interviewees. Those indicators were designed to be used in the day-to-day work with the subsequent data modeling of metrics, to perform data and process mining analysis on the chosen platform. During this phase, the data was uploaded to the tool, and analysis panels and dashboards were created to visualize and make it easier to manage and improve the ODTP. Interviews and workshops were held to gather and validate information and data, especially to improve data and processes.

4.4 Data Analysis

Data analysis was divided into 2 parts. After data validation and sanitization, the 5th phase took place, and 2022 process data was added and analyzed to be compared to 2021 data. The last phase was dedicated to showing and validating the results in a quantitative manner utilizing performance indicators and gathering improvement proposals during interviews with PET and Hospital professionals and leadership. The results were again evaluated by professionals to identify process and data solutions to increase value creation and reduce losses with benefits to the ones waiting for a transplant and their families and relatives. Authors with the support of CET, Hospital, and SC Coordinator professionals analyzed the dashboards, process discovered, conformance analysis and possible problems cause.

5 Results

The research was conducted using data from cases of notification of potential donation for the years 2021 and 2022, provided by the PET. Data were extracted from the medical records and systems used in the hospitals in Rio de Janeiro where this process takes place, and were compiled into an Excel CSV file. In addition, it is relevant to mention that only data that had permission for disclosure and that did not infringe the Brazilian General Law for the Protection of Personal Data (LGPD) was made available for use, and the data were anonymized.

The data from 2021 were extracted in CSV format and included 1012 cases, including 7396 executed events and 11 key process activities, and in 2022, 1152 cases were identified, including 9366 executed events and 12 key process activities, it is noticed that in 2022 there is one more activity, this doesn't mean that there was a change in the process, but that in 2022 we had access to data of the day and time of the beginning of the surgery, which weren't available in 2021. We found detailed information on the day and time of the main activities carried out in the process, characteristics of the donor, hospital, and city of notification, labor tests performed and test results, cause of death, whether an interview was carried out, interviewer capacity, the reason for excluding cases, information on donation and transplantation surgery, and the number of organs collected and transplanted.

To download, configure and create the model from the collected data in CSV format on the selected platform, Celonis, it was necessary to carry out a sequence of steps that are shown in Figure 2.
Once the data was provided, it was necessary to perform modeling and convert the data into the necessary CSV file format to upload the file into the platform. For this, a single CSV file was transformed into two files, the event log (activity table – in appendix 1) which is composed of three main columns, the case ID, activity, and the timestamp in which the activity occurred, and the case detailing table (Case Table in appendix 1).

With the files already available on the platform, a data pool was created, a place within the platform where our data schema would be stored. Within the data pool, it is necessary to create a data model, which consists of identifying the content of the columns of the activities table and selecting a foreign key, which consists of a unique identifier code that makes it possible to compare the two tables. Finally, after the creation of the data pool, the analysis of the mining techniques and the selected indicators were created to evaluate the performance of the ODTP.

Once the construction of analyzes and indicators was completed, it was possible to observe the following results. The discovery analysis showed that the process presents a high variation in its execution, with 263 variants, in 2021 and 360 variants in 2022, an increase of 36.9% in process variability. There is still a long delay between the hospital admission activity and the activity of the first BD evaluation exam, reaching 127.3 hours in the most common variant, in 2021 and 112 hours in 2022, a decrease of 12%. In 2021, the conformance analysis presents a 69 % compliance rate when compared to the model process, in addition, it presents 32 different types of violations, actions that are not foreseen in the process model. In 2022, the conformance increased to 85%, but the model used to compare was more flexible than the model used in 2021. The process models used to check conformance are presented in Figures 5 and 6 and the notations used are like BPMN and explanations are available on Celonis website and academic partnership public training material.

There are some important general data indicated in the analysis of the process: an average of 2.77 cases per day in 2021 and 3.16 in 2022, an increase of 14%; 20 activities performed per day in 2021 increased to 25 in 2022; and average throughput time of 8.61 days in 2021 increased to 9.37 in 2022.
A family denial rate of 29.1 % was identified in 2021, better than the Brazilian average, which was 42 % (ABTO 2022). Although family denial increased to 35 % in 2022. In 2021, the was a loss rate during maintenance of 12.6 %, well above the Brazilian average, and the state of Santa Catarina which is 7 % (ABTO 2022). In 2022, donor maintenance loss decreased to 11.7%. But it can be concluded that there is a great loss of potential donors who do not carry out the donation due to poor maintenance of the donor. Consequently, the conversion rate from eligible donors to effective donors was 39.3 %, in 2021, which is considerably lower than the Brazilian average of 55.4 % (ABTO 2022). In 2022, the conversation rate increased to 36 %, and it can be noticed that even with more cases of BD notification in 2022, these opportunities to save lives were not very well used.

When analyzing the indicators, it was observed that the extraction rate in the state of Rio is 1.04 in 2021 and 0.79 in 2022. When comparing the organ utilization from the same donor, 2021 had an average of 2.26 and 2022 2.12, and the Brazilian average in 2022 organ utilization was 1.29 organs transplanted per donor, which represents the average of donated organs from the same donor, a result lower than expected since the same donor can donate up to 8 organs. In the USA, according to Lewis (2020), using organdonor.gov data, "statistics from 2016 reported an average of 3.54 and 3.06 organs recovered and transplanted respectively per donor, with a total of 4859 (13.8%) organs recovered for transplant and later discarded due to poor organ function, infections, anatomical abnormalities, etc. These data in Brazil are around 2.5 over the years (ABTO 2023). In 2021, regarding the retrieval of extracted organs, it was noticed that only 91.4% of these organs are used and transplanted, and, in 2022, this number increased to 99.5%. The BD identification rate in the state of Rio de Janeiro is 58.4 %, a number close to the Brazilian average of 57.7 % in 2021 (ABTO 2022). And there was an increase to 66.4% in 2022. In addition, in 2021, it was observed that the coronavirus (COVID-19) is the main cause of the exclusion of donations, with 10 % of cases. In 2022, COVID-19 was excluded from the absolute contraindication, and more organs were used to transplant. Additionally, also comparing 2021 to 2022, there is a rate of 54 % of BD notifications with families' interviews conducted, 27 % of cases with a result of donation with retrieval, and 3 % of cases were validated donors without organ retrieval and these rates changed to 64 %, 26 %, and 4 %, respectively.

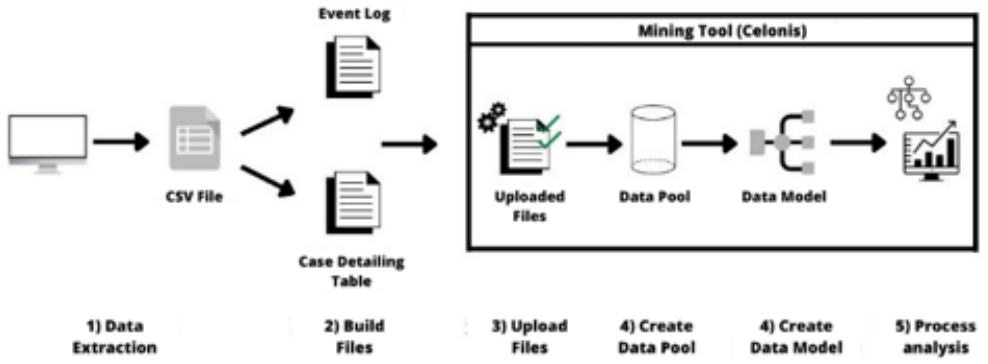

Figure 3. Diagram for using the mining tool.
Source. Moura (2022) based on Arias et al. (2020)

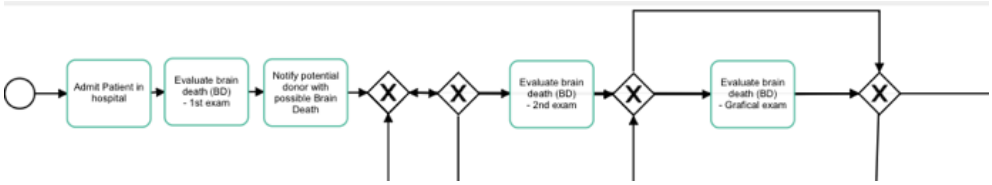

Figure 4. Sample of the model used to check conformance in 2021.
The complete model available at https://bit.ly/comparing21_22

The state of Rio de Janeiro presents a donor profile or epidemiology very close to what is perceived in the Brazilian average, which has a male majority of 58 %, a predominant age group between 50 and 68 years, equivalent to 38 %, with a predominance of blood type O, with 53 % of the cases, and with the predominant cause of death as cerebrovascular accident (CVA - Stroke) with 54 %.

The most important Rio de Janeiro State result was an increase of 15% in organs available for transplant. The BD notification increased also, from 1012 to 1152, but the organ utilized from the same donor decreased from 2.26 to 2.21, and the family denial was higher comparing 2021 and 2022 by 5.9 percentile points, increasing from 120 to 256 refusals, comparing both years. Some of the results are presented in Figures 5, 6, and 7. The analysis results showed a significant delay between the first two activities and arouse some possible discussions. It seems to be crucial to streamline the process and minimize the waiting time to ensure timely evaluation and decision-making regarding organ donation, enhance conformance to the process model, optimize donor maintenance, improve family consent rate, increase conversion rate from eligible donors to effective donors and continuously monitor and evaluate performance.

6 Discussion

To present proposals for improvements based on the analysis, two meetings were held with professionals involved in the donation process of state hospitals in Rio de Janeiro, one with Hospital Estadual Adão Pereira Nunes and another with Hospital Estadual Alberto Torres, and the data and process analysis were explained to PET professionals. The purpose of the meetings and explanations was to present the complete dashboard so they could propose improvements to the ODT Supply Chain and the ODTP.

To have an efficient BD active procurement, and avoid BD under notification or report, the implementation of a 24-hour multidisciplinary unit (CIHDOTT) in the hospital was proposed. With the interview results, it was noticed that this proposal directly impacts the reduction of time to identify BD, as it is possible to notice and compare 2021 and 2022 data. It was possible to confirm the improvement by comparing hospitals that have CIHDOTT or not. Having a 24-hour 7 days CIHDOTT always provides monitoring of cases, since when the hospital does not have this resource, opportunities for identifying BD are lost at times when the CIHDOTT is not working.

Table 2. Workshops Improvement Proposal from 2 selected hospitals

Indicator	Improvement Proposals	Authors supporting Proposal
Active donor procurement	Implementation of a 24-hour CIHDOTT in the hospital	Matesanz and Miranda (2002); Matesanz and Domínguez-Gil (2007); Hoste et al. (2016); Hobeika et al., (2017); Paim and Figueiredo (2019); ABTO (2023)
Donor losses during maintenance	Responsible team formed by nurses; Establish a maintenance protocol in the hospital; Treat cases of brain death in the ICU.	Matesanz and Miranda (2002); Matesanz and Domínguez-Gil (2007); Hoste et al. (2016); Hobeika et al., (2017); Paim and Figueiredo (2019); ABTO (2023)
Quantification of donations and non-donation	Establish a culture of importance and valorization of donation in the hospital	Matesanz and Domínguez-Gil (2007); Hoste et al. (2016); Matesanz et al., (2017) Hobeika et al., (2017); Silva et al. (2021); ABTO (2023)
Family negative or refusal	Reception with compassionated care for family members; Provide information to family members; Train professionals with technical skills.	Matesanz and Domínguez-Gil (2007); Marck et al. (2015), Hoste et al. (2016); Chandler (2017), Hobeika et al., (2017); Araujo and Siqueira (2023), De Andrade and Figueiredo, (2019) ABTO (2023)
Organ utilization rate	Strengthen communication between hospitals and the State Transplant Center.	Shanmugarajah et al. (2014); Andrade and Figueiredo, (2019); Carámbula (2020)
The Supply chain and process in general	Constant training for the team; General alignment of all teams involved in the process; Easy-to-understand and accessible documentation; Create a physical are in the hospital just for potential donors.	Matesanz and Miranda (2002); Matesanz and Domínguez-Gil (2007); Rosendale et al. (2011); Hobeika et al., (2017); Duran, (2017); Arora and Subramanian (2019); Mota et al. (2020); Soares et al., (2020); Cole (2021) Silva et al. (2021); ABTO (2023)

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Figure 5. Process Donation and Transplantation Principal Indicators Monthly 2021 and 2022

Zoom is available at web public site indicated below the Figure 5.
https://bit.ly/comparing21_22

Regarding the reduction of donation losses during maintenance, some improvements were proposed. First, the team responsible for the process is formed by nurses. This allows for greater agility in the process, since they are available and allowed to act in all stages of the process, providing greater autonomy and coordination. Second, establish a maintenance protocol in the hospital, guiding professionals in their work and monitoring the proper functioning of this protocol. Third, treating BD cases within the hospital's ICU, since the ICU has more efficient resources that help with maintenance, compared to the emergency room.

It is noteworthy that establishing a culture of the importance of donation in the hospital is paramount to achieving better results. It was noticed that the use of resources that value the professionals involved gives them a sense of purpose and belonging. These resources are: publicly thank those involved when a donation is made, giving them reinforcement when a donation is made, and continuous investment in professionals through feedback and training.
To reduce the family negative indicator, some improvements were proposed. First, to provide greater acceptance to family members, it is proposed to bring humanization to the process through information given correctly and at the right time. For this, it is important to start talking with family members before the closed BD protocol, to define what BD is and what steps the patient will go through. In addition, having a room reserved for all these conversations, not just the interview, promotes compassion and human care. Second, professionals acquire technical and behavioral skills, to promote continuous education and training about care for family members.

When analyzing the organ utilization indicator, it is noticed that the reduction occurs when there is a refusal of organs by the retrieval surgical team for some reason identified in the act. Therefore, it is necessary to promote an alignment of what is acceptable, so that the potential donor does not go through this whole procedure in vain. Another point would be to evaluate the logistics and communication between the hospitals and the State Transplantation Center, as often the reason for a poor result is the insufficient number of staff and transportation means in the final logistics.
To improve the whole process, it is necessary to constantly provide training to the team, especially about the family interview and maintenance of the potential donor. It is also necessary to promote alignment with those involved in the process and have documentation that is easy to understand and access on what should be included in each activity related to the supply chain and detailed process.

Those propositions are well established, especially, by Matesanz and Domínguez-Gil (2007); Hoste et al. (2016); Hobeika et al. (2017) were confirmed as problems affecting Rio de Janeiro ODTSC. The losses perceived by Paim and Figueiredo (2019) were also present in the process and data. It is paramount to discuss the quality of data and to arise motivation or capacity or even competency to improve the process and the supply chain. Interviewees said the records are not always based on the truth or provided with trustable evidence. For example, how trustable are the causes reported of family denial? Is the hospital coordinator well trained, is there a work environment adequate to offer the right to donate to the family; the one talking to the families is well trained but the previous professionals who

contact the family treated them well? Marck et al. (2015) identify factors relating to consent for organ donation bringing some clues to be further investigated. Chandler (2017) guides how to ask families to consent to organ donation and can be used to go deeper into family refusal as it increased from 2021 to 2022.

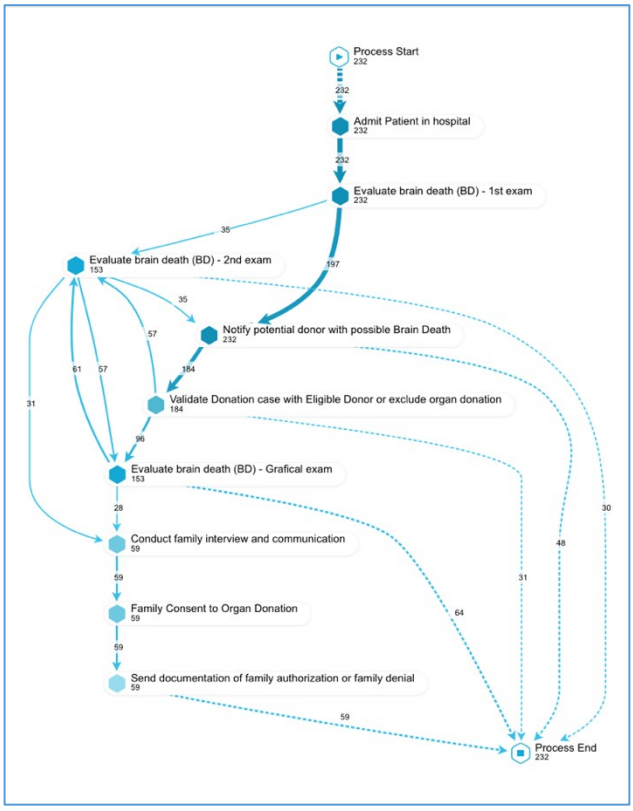

Figure 6. (Left) Process discovered with data and PM – 2022 https://bit.ly/comparing21_22

Figure 7. Dashboards comparing Process Donation and Transplantation Performance Indicators from 2021 and 2022

The research at least in these 155 hospitals demonstrated that PM was applicable to discovering ODTP with the data gathered. The PM visualization made available to PET answered the 1st research question positively. Several limitations must be improved such as increasing evidence to each data provided by professionals and process and records, put the ODTP was better analyzed with PM techniques. Its, although, important to discuss the causes of Rio de Janeiro's Improvement. Related to the 2nd research question, using indicators from literature and tailoring them with PET professionals, and considering Rio de Janeiro, had 15% more organs available for transplant, an important performance improvement, great than the Brazilian average improvement (10%) in the same period. The professionals interviewed and those who were at the workshops and also the research team agree on the utility of the Supply chain and ODTP indicator. Regarding the 3rd question when comparing the ODTSC process and data from 2021 and 2022, it is possible to identify positive impact improvements especially related to the number of cases and organs made available, but we must discuss problems that decrease performance and efficiency, especially family refusal. The technology adoption can be improved the training and learning reinforcement and the research must continue to increase and discover a stronger correlation to the benefits Rio de Janeiro society with more organs available to transplant and to reduce suffering while waiting for this supply chain speed up, quality, efficiency, and effectiveness.

7 Conclusion

The research has shown that PM can be used to analyze process and supply chain performance. Comparing 2021 and 2022, it was observed an increase of 15% in the number of organs donated and made available for transplant, and improve or even save lives, with the most cost-effective alternative to whom is with a potentially fatal organ failure. The effects of process transparency, in general, can be useful to benefit society with more opportunities to save or improve quality of life and reduce transplant queues. The research generates new knowledge and creates opportunities for other academic studies. To healthcare professionals and, specifically, to ODT ones, the work can stimulate using technologies to enhance how the whole organ donation and transplantation supply chain is designed, managed, and improved. To society it is important to consider donation as the best alternative for those in need of transplants and their quality of life and, in most cases, their lives depend on ODTSC improvements. The limitations of the research were: we only had access to data referring to Rio de Janeiro; it was not, yet, possible to train more professionals on how to use the PM tool and use the data to improve each hospital process and improvements are still being made in the data and the process. The literature review was not systematic, but it helped the researchers and practitioners deal with concepts and practices.

As future research possibilities, we propose integrating artificial intelligence with PM techniques. Combining these two knowledge areas can provide future planning and more effective decision-making based on historical data captured in event logs, learning recurrently, and making it possible to identify the connection between cause and effect, demonstrating where the failures are. We propose to add more data referring to periods, before and after the pandemic, observe how professionals manage to improve their processes using techniques and tools themselves, and use PM to improve the quality of data, communication, and coordination between units, and in particular, use to improve the digitalization of processes, preserving humanization and empathy throughout the whole ODT system. Society increases hope in life with an ever-improving and better-managed organ donation and transplantation supply chain and process.

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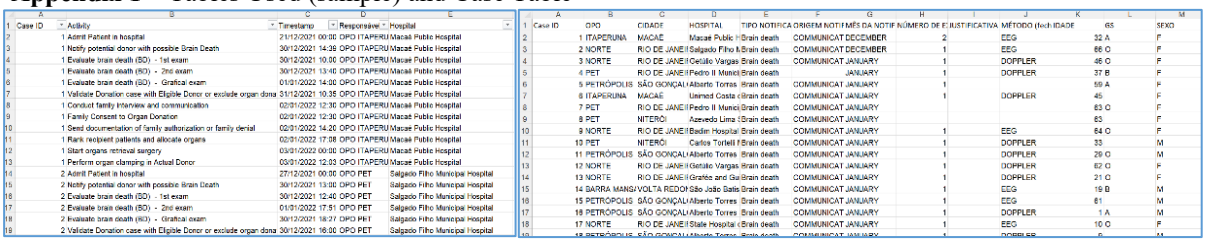
Appendix 1 – Tables Used (sample) and Case Table



	A	B	C	D	E
1	Case ID	Activity	Timestamp	Responsável	Hospital
2		1 Admit Patient in hospital	21/12/2021 00:00	OPO ITAPERU	Macaé Public Hospital
3		1 Notify potential donor with possible Brain Death	30/12/2021 14:39	OPO ITAPERU	Macaé Public Hospital
4		1 Evaluate brain death (BD) - 1st exam	30/12/2021 19:00	OPO ITAPERU	Macaé Public Hospital
5		1 Evaluate brain death (BD) - 2nd exam	30/12/2021 13:40	OPO ITAPERU	Macaé Public Hospital
6		1 Evaluate brain death (BD) - Gratical exam	01/01/2022 14:00	OPO ITAPERU	Macaé Public Hospital
7		1 Validate Donation case with Eligible Donor or exclude organ dona	31/12/2021 19:35	OPO ITAPERU	Macaé Public Hospital
8		1 Conduct family interview and communication	02/01/2022 12:30	OPO ITAPERU	Macaé Public Hospital
9		1 Family Consent to Organ Donation	02/01/2022 12:30	OPO ITAPERU	Macaé Public Hospital
10		1 Send documentation of family authorization or family denial	02/01/2022 14:20	OPO ITAPERU	Macaé Public Hospital
11		1 Rank recipient patients and allocate organs	02/01/2022 17:08	OPO ITAPERU	Macaé Public Hospital
12		1 Start organs retrieval surgery	03/01/2022 00:00	OPO ITAPERU	Macaé Public Hospital
13		1 Perform organ clamping in Actual Donor	03/01/2022 12:03	OPO ITAPERU	Macaé Public Hospital
14		2 Admit Patient in hospital	27/12/2021 00:00	OPO PET	Salgado Filho Municipal Hospital
15		2 Notify potential donor with possible Brain Death	30/12/2021 13:00	OPO PET	Salgado Filho Municipal Hospital
16		2 Evaluate brain death (BD) - 1st exam	30/12/2021 12:40	OPO PET	Salgado Filho Municipal Hospital
17		2 Evaluate brain death (BD) - 2nd exam	01/01/2022 17:51	OPO PET	Salgado Filho Municipal Hospital
18		2 Evaluate brain death (BD) - Gratical exam	30/12/2021 18:27	OPO PET	Salgado Filho Municipal Hospital
19		2 Validate Donation case with Eligible Donor or exclude organ dona	30/12/2021 16:00	OPO PET	Salgado Filho Municipal Hospital

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	Case ID	OPO	CIDADE	HOSPITAL	TIPO NOTIFICA	ORIGEM NOTIF	MÊS DA NOTIF	NÚMERO DE E	JUSTIFICATIVA	MÉTODO (tech	IDADE	GS	SEXO
2		1 ITAPERUNA	MACAE	Macaé Public H	Brain death	COMMUNICAT	DECEMBER	2		EEG	32	A	F
3		2 NORTE	RIO DE JANEI	Salgado Filho N	Brain death	COMMUNICAT	DECEMBER	1		EEG	66	O	F
4		3 NORTE	RIO DE JANEI	Getúlio Vargas	Brain death	COMMUNICAT	JANUARY	1		DOPPLER	46	O	F
5		4 PET	RIO DE JANEI	Pedro II Munici	Brain death		JANUARY	1		DOPPLER	37	B	F
6		5 PETRÓPOLIS	SÃO GONÇALI	Alberto Torres	Brain death	COMMUNICAT	JANUARY	1			59	A	F
7		6 ITAPERUNA	MACAE	Unimed Costa	Brain death	COMMUNICAT	JANUARY	1		DOPPLER	45		F
8		7 PET	RIO DE JANEI	Pedro II Munici	Brain death	COMMUNICAT	JANUARY				83	O	F
9		8 PET	NITERÓI	Azevedo Lima	Brain death	COMMUNICAT	JANUARY				83		F
10		9 NORTE	RIO DE JANEI	Badim Hospital	Brain death	COMMUNICAT	JANUARY	1		EEG	64	O	F
11		10 PET	NITERÓI	Carlos Tortelli	Brain death	COMMUNICAT	JANUARY	1		DOPPLER	33		M
12		11 PETRÓPOLIS	SÃO GONÇALI	Alberto Torres	Brain death	COMMUNICAT	JANUARY	1		DOPPLER	29	O	M
13		12 NORTE	RIO DE JANEI	Getúlio Vargas	Brain death	COMMUNICAT	JANUARY	1		DOPPLER	62	O	F
14		13 NORTE	RIO DE JANEI	Gratão and Gui	Brain death	COMMUNICAT	JANUARY	1		DOPPLER	21	O	F
15		14 BARRA MANSA	VOLTA REDON	São João Batis	Brain death	COMMUNICAT	JANUARY	1		EEG	19	B	M
16		15 PETRÓPOLIS	SÃO GONÇALI	Alberto Torres	Brain death	COMMUNICAT	JANUARY	1		EEG	61		M
17		16 PETRÓPOLIS	SÃO GONÇALI	Alberto Torres	Brain death	COMMUNICAT	JANUARY	1		DOPPLER	1	A	M
18		17 NORTE	RIO DE JANEI	Stella Hospital	Brain death	COMMUNICAT	JANUARY	1		EEG	10	O	F
19		18 PETRÓPOLIS	SÃO GONÇALI	Alberto Torres	Brain death	COMMUNICAT	JANUARY	1		DOPPLER	6		M

Biographies

Rafael Paim is the Author of Process Management: Think, Act and Learn, Bookman, the best-selling BPM book in Brazil. In addition, he is the Editor of the BPM Journal and the author of over 50 articles on Process Management. Professor at Centro Federal de Educação Tecnológica Celso Suckow da Fonseca Cefet-RJ, Production Engineering Department. Has graduated in Production Engineering from Universidade Federal do Rio de Janeiro (2001), has a master's in Production Engineering from Universidade Federal do Rio de Janeiro (2002), and a PhD in Production Engineering from Universidade Federal do Rio de Janeiro (2007), complemented by a PhD sandwich in Computer Science from Carnegie Mellon University (2007). In 2016, he finished his post-doctoral program at CES-COPPEAD/UFRJ. Rafael has experience in Production Engineering, focusing on Processes and acting on the following subjects: process, process management, process improvement, and organization design. Healthcare and organ donation processes are his main area of experience. He has publications in Scientific Journals (National/International); 4 Books published; and more than 40 Articles in Annals of Events (National/International).
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Pedro Senna is a Post-Doctorate in Production Engineering (COPPE/UFRJ). PhD in Production Engineering from PPPRO CEFET/RJ. Master in Production Engineering from PUC-Rio. Specialization in Business Intelligence by PUC-Rio. Degree in Production Engineering from CEFET/RJ. Professor of the Graduate Course in Production Engineering at CEFET/RJ and professor at the Graduate Program in Production and Systems Engineering (PPPRO) at CEFET/RJ. 15 years of experience in projects involving indicators and logistics and with research in the area of Risk Management in supply chains, Business Process Management, Omnichannel, Smart Cities, Lean/Six-Sigma, and Circular Economy. He has publications: 34 Articles in Scientific Journals (National/International); 02 Books published; 70 Articles in Annals of Events (National/International).

Amanda Costa is a Researcher and Consultant focused on Process Management and Lean Healthcare. Graduated in Production Engineering from CEFET-RJ and post graduated in Quality Management in Health Services from Hospital Albert Einstein. She works as a volunteer and researcher at ADOTE since 2012 (www.adote.org.br). Participated in Lean Office projects at Embraer, Cteep, SIG Combibloc, Firjan, Senai among many others. He worked on Lean projects in the graphic sector of RJ and in private and public hospitals such as Hospital de Saracuruna/RJ, Alberto Torres/RJ, Perinatal/RJ, Unimed VR. Specialist in Organ and Tissue Donation processes, having carried out works in RJ, SC and SP. Integrated Process Management Certification (140h). Trained dozens of In Company professionals

using constructivist methodology, with experience in projects in the areas of Processes, with specialization in Lean Manufacturing, Lean Office and Lean Healthcare. He worked in Process Governance Projects such as at Fapes/BNDES, at the National Electric System Operator (ONS) and in projects to improve processes and structure at the Itaipu Technological Park.

Letícia Moura is researcher and Consultant. Graduated in Production Engineering from CEFET-RJ. She works as a volunteer and researcher at ADOTE since 2019. As well as she acted through the work of the conclusion of the undergraduate course in the health sector in the application of process mining and construction of dashboards for the process of donation and transplantation. She participated in the project to implement the organizational design function in the strategic transformation area of ONS. She participated in the structuring of the processes area of the company Start Up inChurch and was responsible for creating the processes in the customer success and financial areas of the same company. In addition, she worked on CRM and other platform integration projects and process automation. She worked on the construction of dashboards for monitoring processes in the areas of technology, finance and customer success. She has certification in Customer Data Analytics by CS Academy and Power BI Desktop Certification by Alura. And she also has several Celonis training certificates and training.

Alexandre Cauduro is a Director of the State Transplant Center of the State of Rio de Janeiro and Coordinator of the Pediatric Heart Transplant Program at the National Institute of Cardiology. He is Doctor of Medice at Universidade Federal do Rio de Janeiro, Pediatrics Residency Program was at Universidade Estadual de Campinas. Pediatric Cardiology Fellowship and Pediatric Echocardiography at Universidade de São Paulo. Clinical and Research Fellowship in Pediatric Heart Failure and Transplantation at University of Alberta.

Cláudia Araujo is Associate Professor of the COPPEAD Graduate School of Business of the Federal University of Rio de Janeiro - COPPEAD / UFRJ, and Coordinator of the Center for Health Care Studies – CES-COPPEAD/UFRJ. She holds a CNPq Research Productivity Scholarship and a FAPERJ scholarship as Cientista do Nosso Estado – FAPERJ 2022. She is certified by the MIT Sloan School of Management in Business Design for Digital Transformation and is a facilitator in the Lego Serious Play methodology. Graduated in Economics from Pontifical Catholic University of Rio de Janeiro PUC / RJ, she holds a Ph.D. and a Master's degree in Administration from COPPEAD/UFRJ. She was a Visiting Researcher at Maryland University - Robert Smith School of Business (USA) in 2004. She researches innovation in health care, Design Thinking and Design Services applied to healthcare services, quality and efficiency in health services, patient adherence to medical treatment, and the organ donation and transplantation process. She is a member of the Scientific Editorial Board of the Journal of Business Administration (RAE) and the Journal of Operations and Supply Chain Management (JOSCM). She has articles published in national and international journals, among which stand out: International Journal of Services and Operations Management; Health Care Management Science; Transplantation Proceedings; Revista Panamericana de Salud Publica; Service Industries Journal; Cadernos de Saúde Pública; Cadernos EBAPE.BR; Leadership in Health Services, among others. http://orcid.org/0000-0003-0290-4807