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PERFORMANCE ANALYSIS OF ORGAN DONATION AND TRANSPLANTATION SERVICES IN BRAZIL

Rio de Janeiro

2020

Marina Martins Siqueira

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A thesis presented to the Instituto Coppead de Administração, Universidade Federal do Rio de Janeiro, as part of the mandatory requirements for the degree of Doctor of Sciences in Business Administration (D.Sc.)

Advisor: Prof. Claudia Affonso Silva Araujo

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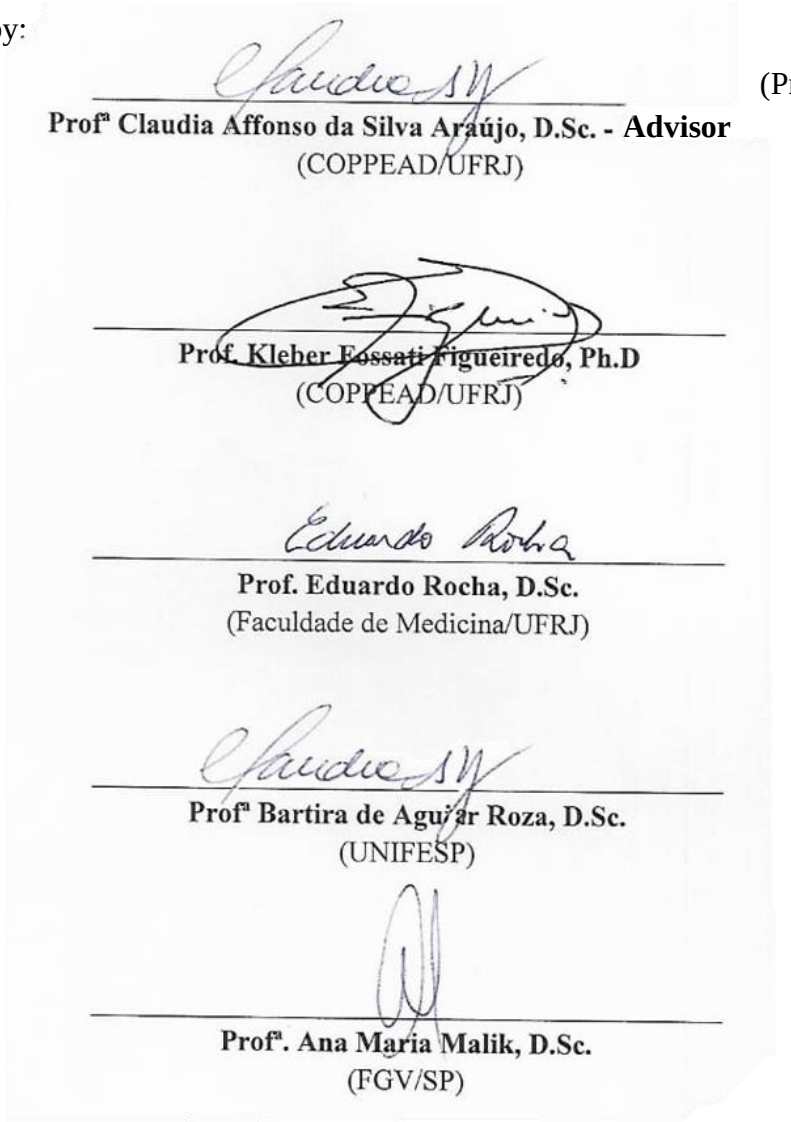

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ABSTRACT

SIQUEIRA, Marina**. Performance analysis of organ donation and transplantation services in Brazil**. Rio de Janeiro, 2020. Tese (Doutorado em Administração) - Instituto COPPEAD de Administração, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 2020.

The performance appraisal of health services is critical to uncover inefficiency points, as well as to benchmark and monitor results, allowing corrective actions that lead to quality and effectiveness improvements. The assessment is especially valuable when it comes to intricated processes such as those comprising organ donation and transplantation activities. In this scenario, this doctoral thesis aims to explore the performance of organ donation and transplantation services, particularly within the Brazilian National Transplant System. The thesis is structured as a set of three articles, with research methods that aim at different outlooks on the same phenomenon. The first article sought to identify, through a systematic search in the literature, indicators used to monitor and manage donation-transplantation processes. The second one targeted the estimation and benchmark of technical and scale efficiency for Brazilian federal units performing kidney transplants, using data envelopment analysis to examine the conversion of physical and labor inputs into transplants. The third one explored, through semi-structure interviews with Brazilian state transplant coordinators, the factors that influence the performance of donation-transplantation services. In parallel, a survey study analyzed, for medical and nursing personnel of Brazilian hospitals, the attitude and factors associated with a favorable attitude towards organ donation. Finally, a second supplementary article systematically reviewed the literature addressing the types and content of innovation on donation-transplantation services. The first article indicated knowledge gaps and lack of monitoring standardization for important stages of the process, such as the logistical path to distribute donated organs, and the quality of life of transplanted patients. The second article suggested significant performance disparity between Brazilian states and regions, and that most states operate in a technically inefficient manner, implying that better results could be achieved with current amount of physical, material and human resources employed. The third article revealed a comprehensive set of factors affecting the services performance. They include the relationship with hospitals performing donation-transplantation, the use of indicators as a basic management tool, the importance of political stability and political will towards

donation-transplantation activities, and, the need for better selection, training and motivation of professionals performing or managing these services, covering technical knowledge, relational skills and a compatible interpersonal profile. The first supplementary article indicated that a favorable attitude of healthcare professionals towards organ donation relates to socio-personal variables, such as having spoken with family members about organ donation and feeling proud of working in this health field. These associations provide insights on how to improve the confidence and attitude of healthcare professionals. Finally, the second complementary article drew attention to the fact that mapped innovations predominantly focus on clinical aspects, such as transplant surgical techniques. Studies scarcely addressed how the innovation process in this field can be effectively managed and how management tools and knowledge can be applied into donation-transplantation innovations. Altogether, the studies' results converge to indicate limited professionalization in the management of Brazilian organ donation-transplantation services, with the need for managerial actions pervading several stages of its process. In order to improve the performance of the examined donation-transplantation services, the research presents the following managerial implications, regarding to the need of: a) Diversifying the methods of performance measurement, while checking validity and reliability issues; b) Addressing knowledge gaps concerning quality domains; c) Reassessing the services optimal operation size and distribution across states; d) Reducing managerial wastes, in order to better allocate available resources; e) Revising the training, remuneration and motivation strategies for those performing or managing the services; f) Investing in innovation-focused research. Given the paucity of studies that systematically examine the performance in this field, and, by providing a better understanding of improvement areas and potential means to address them, this research intend be useful for researchers, managers, practitioners and policy makers on organ donation-transplantation, drawing closer the medicine and healthcare management domains.

Keywords: Organ Donation and Transplantation; Healthcare Services; Unified Health System; Brazil; Performance Analysis; Efficiency Estimation.

RESUMO

SIQUEIRA, Marina**. Análise de desempenho dos serviços de doação e transplante de órgãos no Brasil.** Rio de Janeiro, 2020. Tese (Doutorado em Administração) - Instituto COPPEAD de Administração, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 2020.

A avaliação do desempenho de serviços de saúde é fundamental para descobrir pontos de ineficiência, bem como para comparar e monitorar resultados, permitindo ações corretivas que levam a melhorias de qualidade e eficácia. A avaliação é especialmente valiosa quando se trata de processos complexos, como aqueles que compreendem atividades de doação e transplante de órgãos. Nesse cenário, esta tese de doutorado tem como objetivo examinar o desempenho dos serviços de doação e transplante de órgãos, particularmente no Sistema Nacional de Transplantes. A tese está estruturada em um conjunto de três artigos, com métodos de pesquisa que visam diferentes perspectivas sobre o mesmo fenômeno. O primeiro artigo procurou identificar, através de uma pesquisa sistemática na literatura, indicadores utilizados para monitorar e gerenciar os processos de doação-transplante. O segundo teve como objetivo estimar e realizar o *benchmarking* da eficiência técnica e de escala dos estados brasileiros que realizaram transplantes renais no período analisado, empregando a análise de envelope de dados para examinar a conversão de recursos, humanos e físicos, em transplantes. O terceiro explorou, por meio de entrevistas semiestruturadas com coordenadores estaduais de transplante, os fatores que influenciam positivamente ou negativamente o desempenho nos brasileiros serviços de doação-transplante. Paralelamente, uma pesquisa baseada em questionário examinou, para médicos e enfermeiros de hospitais brasileiros, a atitude e os fatores associados a uma atitude favorável em relação à doação de órgãos. Por fim, um segundo artigo suplementar revisou sistematicamente a literatura abordando os tipos e o conteúdo da inovação nos serviços de doação-transplante. O primeiro artigo indicou lacunas de conhecimento e falta de padronização do monitoramento para etapas importantes do processo, como o caminho logístico para a distribuição de órgãos doados e a qualidade de vida dos pacientes transplantados. O segundo artigo sugeriu disparidade significativa de desempenho entre estados e regiões brasileiras, onde a maioria dos estados opera de maneira tecnicamente ineficiente, indicando que melhores resultados em termos de números de transplantes poderiam ser alcançados com a quantidade atual de recursos empregados. O terceiro artigo revelou

um conjunto abrangente de fatores que afetam o desempenho dos serviços, incluindo o relacionamento com hospitais que realizam doações e/ou transplantes, o uso de indicadores como ferramenta básica de gestão, a importância da estabilidade e vontade política para este campo da saúde, e a necessidade de uma melhor seleção, treinamento e motivação dos profissionais que realizam ou gerenciar esses serviços, cobrindo conhecimentos técnicos, habilidades relacionais e um perfil interpessoal compatível. O primeiro artigo suplementar indicou que uma atitude favorável dos profissionais de saúde em relação à doação de órgãos se relaciona a variáveis sócio-pessoais, como já ter conversado com familiares sobre doação de órgãos e sentir orgulho de trabalhar nesse campo da saúde. Essas associações fornecem informações sobre como melhor endereçar a autoconfiança e a atitude destes profissionais. Por fim, o segundo artigo suplementar chamou a atenção para o fato de que as inovações mapeadas se concentram em torno de aspectos clínicos como técnicas cirúrgicas de transplante. Os estudos pouco abordaram como o processo de inovação pode ser efetivamente gerenciado e como as ferramentas e o conhecimento da gestão de serviços de saúde podem ser aplicados às inovações em doação-transplante de órgãos. Ao todo, os resultados dos estudos convergem para indicar profissionalização limitada no gerenciamento dos serviços brasileiros de doação-transplante, com a necessidade de ações gerenciais que permeiam várias etapas de seu processo. Para melhorar o desempenho dos serviços examinados, a pesquisa apresenta as seguintes implicações gerenciais, no que diz respeito à necessidade de: a)Diversificar os métodos de medição de desempenho, verificando questões de validade e confiabilidade; b) Abordar as lacunas de conhecimento relativas aos domínios da qualidade; c) reavaliar o tamanho ótimo da operação e distribuição dos serviços entre os estados; d) Reduzir desperdícios gerenciais, a fim de alocar melhor os recursos disponíveis; e) Revisar estratégias de treinamento, remuneração e motivação de profissionais que executam ou gerenciam os serviços; f) Investir em pesquisas focadas na inovação. Dada a escassez de estudos que examinam sistematicamente o desempenho nesse campo e, ao proporcionar uma melhor compreensão das áreas de melhoria e dos meios possíveis para abordá-las, esta pesquisa pretende ser útil para pesquisadores, gestores, profissionais e formuladores de políticas de doação e transplante de órgãos, aproximando os domínios da medicina e da gestão de serviços de saúde .

Palavras-chave: Doação e Transplante de Órgãos; Serviços de Saúde; Sistema Único de Saúde; Brasil; Análise do Desempenho; Estimação da eficiência.

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

BVS: Virtual Health Library

CRS: Constant Return to Scale

DEA: Data Envelopment Analysis

DMU: Decision-Making Unit

GDP: Gross Domestic Product

GODT: Global Observatory of Organ Donation and Transplantation

ICU: Intensive Care Unit

KMO: Kaiser-Meyer-Olkin

ODT: Organ Donation and Transplantation

OPO: Organ Procurement Organization

PMP: Per Million of Population

RBT: Brazilian Transplant Registry

SE: Scale Efficiency

SUS: Unified Health System

VRS: Variable Return to Scale

WHO: World Health Organization

SUMMARY

1. INTRODUCTION

1.1. Performance assessment

Performance assessments comprise a range of management tools used to measure a particular organization, individual(s), activity, service or process. Its use in healthcare systems around the world is a extensively adopted practice, covering a wide spectrum of clinical, socioeconomic and managerial dimensions such as mortality and morbidity, income and educational levels of patients, hospital spending and physical infrastructure (Bevan et al., 2018; Otley, 1999).

The performance benchmark enables to assess quality and effectiveness domains of health services. Internal benchmarking allows assessing changes and trends over time, comparing current and previous performance within the same unit of analysis. In turn, external benchmarking look at the performance among comparable organizations in a given sector, making it possible to rank results and to signalize gold standards as well as unacceptable performance levels. These appraisals may support decision making on resource allocation, guide the implementation of quality programs, point the need for educational or cost reduction initiatives, bring greater transparency to the measured processes and ground the necessity for behavior changes at healthcare providers (de Vos et al., 2009; Rozados, 2005; Bittar, 2001; Larson and Mercer, 2004).

The performance measurement refers to the process of quantifying the efficiency and effectiveness of past actions, tackling how well organizations are managed and the value they deliver for customers and other stakeholders (Moullin, 2007). There is a growing need - from health users, government, the media, health managers and the general population - to access and compare health services performance through transparent and reliable data, especially those made publicly available. The content of these performance metrics can range from simple descriptive epidemiological data to more complex and abstract aspects as equity and customer satisfaction dimensions (Larson and Mercer, 2004).

The investigation conducted in this doctoral thesis focused on the performance of organ donation-transplantation (ODT) services. Although there is not a universally accepted definition, the performance as discussed in this research can be defined as the extent to which the various aspects of the ODT services – in terms of its structure, processes and outcomes – meet their objectives. The first aspect is the structural setting where the service takes place, encompassing internal policies, physical infrastructure, material, financial and human resources employed. The second one represents the processes of care, regarding treatment, prophylaxis, diagnostics or

patient monitoring. The third domain refers to the outcomes of care, that, in the case of ODT services, can be exemplified as an organ transplantation, a graft rejection episode or the time of survival of a transplanted patient (Institute of Medicine, 2001; Donabedian 1990).

1.2. Organ donation-transplantation services

In 2018 Brazil celebrated 3 decades of its Unified Health System (SUS), one of the largest in the world to provide universal access to health actions and services. SUS represents a major breakthrough in healthcare social inclusion, by means of a right guaranteed in the Brazilian constitution for all its citizens and residents (Celuppi et al., 2019). Since its institution, SUS has undergone several regulatory and managerial improvements and has included in its list of activities several new health services and actions.

Among them, the National Transplant System was established in 1997, aimed at regulating organ and tissue donation and transplantation activities in the national territory. For a better insight on its operation, appendix 1 depicts landmark legislation for ODT in Brazil.

Currently, Brazil has the largest public program of organ transplantation in the world, only behind the United States in absolute number of surgeries (RBT, 2018). Every Brazilian patient with a chronic disease that depends on a transplant has the right to receive an organ through SUS. As a result, more than 90% of the transplants are financed with public funds, including all transplant-related appointments, procedures and surgery (http://portalms.saude.gov.br/).

Besides allowing improved survival and quality of life for thousands of patients, the transplants often replace financially and socially costly therapies. A study comparing the direct medical costs between kidney transplantation and replacement therapies in the SUS context revealed that, in a four-year period, kidney transplantation from a deceased donor generates savings per patient of R$37,000 and R$74,000 in relation to hemodialysis and dialysis, options, respectively (Silva et al., 2016).

Regardless of improvements in ODT rates, in 2018 there were 33,454 patients on the transplant waiting list. The numbers signalize challenges not only to increase donation rates, but also to maximize the effectiveness of the donation process (RBT, 2018). Additionally, the complexity is a striking feature of this healthcare field, as portrayed in the process mapping of appendix 2, detailing the main actors and sequence of activities involved in the Brazilian ODT services. The services comprise the participation of multidisciplinary teams in intensive care units

(ICUs), immunology laboratories, transplant centers and Organ Procurement Organizations (OPOs), including neurologists, intensivists, hospital transplant coordinators, donation and transplant teams. It also requires the construction of a regulatory apparatus to legally specify the way organs can be donated, procured, distributed and transplanted, and delegate attributions across institutions. Each one of the stages mapped present many possibilities for technical and human errors that obstruct the continuity of ODT processes (Matesanz et al., 2009).

Despite the mentioned challenges, there are few studies focused on understanding the performance of ODT services in Brazil, and how these processes can be managed more efficiently (Tong, Morton & Webster, 2016). The appraisal of health services performance is critical to uncover inefficiencies, as well as to benchmark and monitor results, allowing corrective actions that lead to quality and effectiveness improvements (Bevan et al., 2018; Otley, 1999). The assessment is especially useful when it comes to intricated processes as ODT services, with technically complex medical procedures and intense human participation in time-sensitive and simultaneous actions involving multidisciplinary teams located at different organizations (Matesanz et al., 2009).

In this scenario, this doctoral thesis aims to explore the measurement and identification of factors positively or negatively affecting the performance of ODT services, particularly in Brazil. As portrayed in table 1, the thesis is structured as a set of three sequential and two complementary articles, with methodological designs that aim at different outlooks on the same phenomenon. The thesis is structured as follows. After this common introduction, the articles are presented in sections two to six, respectively. Each article contains an introduction, methods, results and concluding remarks section, in addition its own references, tables and figures. Section seven presents the common conclusion, for the doctoral thesis as a whole, referring to its contributions, managerial implications, limitations and indications of future research avenues, followed by its references and appendices.

Table 1. Summary of articles

First article
• **Title**: Performance indicators to assess the organ donation and transplantation process: A systematic review of the literature • **Status**: Published – Pan American Journal of Public Health; IF: 0.77. • **Research question**: What are the performance indicators used in the literature to monitor and manage organ donation-transplantation services? • **Method**: Systematic literature review.
Second article
• **Title***:* Efficiency of Brazilian public services of kidney transplantation: Benchmarking Brazilian states via data envelopment analysis. • **Status**: Published – International Journal of Health Planning and Management; IF: 2.303 • **Research question**: What is the technical and scale efficiency of Brazilian states regarding kidney transplantation services? • **Method**: Efficiency estimation through Data Envelopment Analysis.
Third article
• **Title**: Exploring State Transplant Coordinators' views on factors influencing the performance of organ donation and transplantation services: A qualitative study in Brazil • **Status**: Submitted for publication – Qualitative Heath Research; IF: 3.03. • **Research question**: What are the main factors, as perceived by Brazilian state transplant coordinators, positively or negatively affecting the performance of organ donation-transplantation services? • **Method**: Qualitative study using semi-structured interviews.
First supplementary article
• **Title**: Brazilian Healthcare Professionals: A Study of Attitudes Toward Organ Donation. • **Status**: Published - Transplantation Proceedings; IF: 0.959. • **Research question**: What is the attitude towards organ donation of medical and nursing personnel at two Brazilian hospitals? What socioeconomic and personal variables are associated with a positive attitude? • **Method**: Survey-based study, aimed at statistical associations.

Second supplementary article

- **Title**: Innovations in Organ Donation and Transplantation Services: Systematic Review of Literature
- **Status**: Published – Revista de Administração Hospitalar e Inovação em Saúde; B3.
- **Research question**: What are, and what is the main focus of, the innovations applied to organ donation-transplantation services?
- **Method**: Systematic literature review.

2. FIRST ARTICLE – Performance indicators to assess the organ donation and transplantation process: A systematic review of the literature

Status: Published.

Authors: Siqueira, M.; Araujo, C.; Roza, B.; Schirmer, J.

Journal: Pan American Journal of Public Health (PAJPH).

Journal information: PAJPH publishes original research in the field of public health, including public health policy, health systems and services and research methodology. The journal is published by practice the Pan American Health Organization (PAHO), headquartered in the United States – D.C.

Journal metrics: H-index, 51. 2017 Impact Factor: 0.77.

Abstract

Objective. This study aims to identify, through a systematic search in the literature, indicators used to monitor and manage organ donation and transplantation processes, subsequently grouping these indicators into broader categories.

Method. A systematic review of the literature was carried out in the following databases: Virtual Health Library (BVS), EBSCO, Emerald, ProQuest, Science Direct, and Web of Science. The following search terms, as well as its corresponding terms in Spanish and Brazilian Portuguese, were employed: "efficiency," "indicators," "organ donation," "tissue and organ procurement," and "organ transplantation." Of the 344 articles retrieved, 23 original articles were selected and reviewed for analysis of performance indicators.

Results. The review revealed 117 performance indicators, which were grouped according to similarity of content and divided into three categories. The first one refers to 71 indicators related to the organ donation stage, covering mortality statistics, brain death report, donors' clinical status, medical contraindications to organ donation, family consent to organ donation, actual number of organ donations and procurements. The second one comprises 22 indicators related to organ transplantation activities, including the surgical procedure per se and post-transplantation follow-up. The third category is formed by 24 indicators related to the demand of organs for transplant and the hospitals' resources applied in donation-transplantation processes.

Conclusions. This study allowed to identify which donation-transplantation activities are frequently or scarcely measured through indicators and to map these measures into meaningful

groups. The high number of indicators described in the literature indicates researchers' interest to track performance in this area. Nonetheless, there is little standardization of the indicators used. Also, most indicators focus on donation activities, suggesting knowledge gaps at other stages. Additional indicators are needed to monitor important domains of the donation-transplantation process, such as the number of organs lost due to logistical problems and the patients' quality of life after the transplant surgery.

Key words

Tissue and organ procurement; organ transplantation; indicators; efficiency; review.

2.1. Introduction

Organ transplantation can be defined as a surgical technique used to replace organs of a recipient with organs of a donor, restoring physical function and ensuring the survival of the recipient (1). As transplantation is often the only clinical option for individuals with severe functional impairment of one or more vital organs, the management of ODT activities has great social and public health relevance (2).

The process of donation and transplantation may take place from both living donors or deceased donors with confirmed brain death, following a specific protocol for each of these situations (1, 3). The present study focuses on the ODT from deceased donors[1]. In such cases, from the identification of a potential donor, tests are performed to confirm the brain death diagnosis and rule out clinical contraindications that may pose risks to recipients (4). Then, family members of the potential donor are interviewed, and the organ donation option is clarified. If the family consent is obtained, the search for recipients is initiated, according to immunological compatibility tests between donor and recipient (3). Meanwhile, the donor's cardiorespiratory function is artificially maintained by medical devices and medications. Finally, the organs are removed, hemodynamically maintained and distributed to the transplantation site (3).

[1] *It is important to discern potentially confounded nomenclatures. Namely: a) possible donors, b) potential donors, c) effective donors and d) actual donors. Possible donors refer to deceased patients with no medical contraindications to organ donation. In turn, potential organ donors are those deceased patients with an initiated and/or completed diagnosis of brain death and no medical contraindications for donation. Effective donors refer to patients with at least one organ removed and deemed suitable for transplantation, while actual donors are the effective donors where at least one procured organ was transplanted.*

Even with scientific and technological advances in both medicine and health management fields, there are still many cases of lack of resources and inefficiency in the management and monitoring of this process (5). The ODT efficiency, as targeted in this study, is indicated by the relationship between inputs and outputs. That is, the amount of resources applied in the process or activity (such as the number of organs offered, of available intensive care beds, the materials used, staff and other professionals) and the quantifiable results or health outcomes generated (as the number of transplants performed and the survival rates) (6).

It is worth noting that the disproportion between organ demand and supply and the consequent increase in transplant waiting lines are recurring obstacles; and organ scarcity can be caused either by low donation rates or by inefficient use of donated organs (7, 8). In this context, preventable organ loss should deserve special attention from health managers (3, 9). To monitor the process, indicators that reflect aspects such as hospitals donation and transplantation potential, structural characteristics and resources that impact the ODT activities, human errors and causes of potential donors' loss may be used (10).

Following indicators over time is critical for assessing performance and correcting inefficiencies (11, 12). However, to effectively improve the management of ODT process globally, countries need to possess a pool of reliable and standardized measures that allow the exchange of successful information and practices between different regions of the world (13). Due to the practical relevance of this field, studies aimed to investigate how the efficiency of ODT activities are monitored may contribute to locate and subsequently tackle inadequacies that may impact waiting lines and transplant access (14, 15).

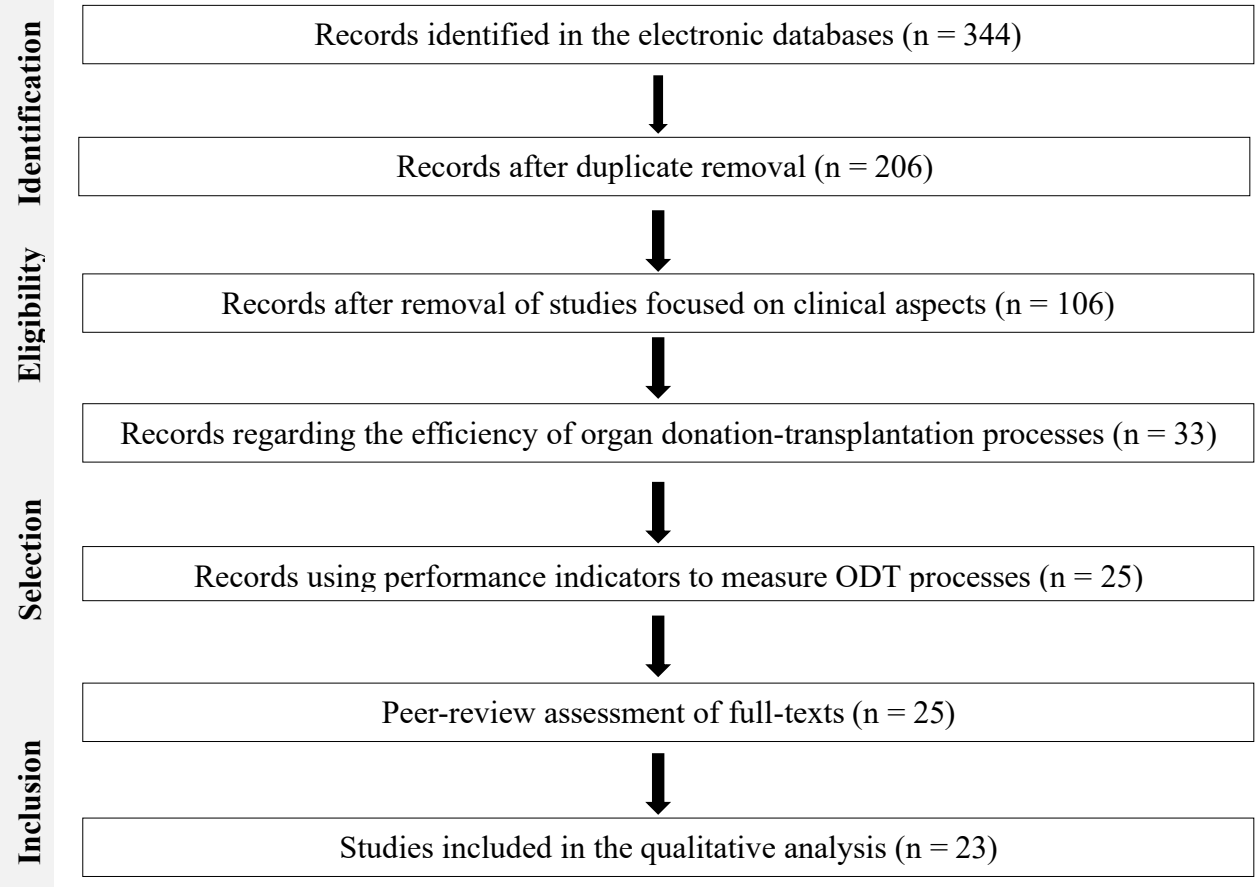
In this context, the aim of this study is to verify, through a systematic literature review, the indicators used to monitor and control the process of organ donation and transplantation and to elaborate a panel to typify the indicators described in the literature.

2.2. Methods

The method chosen for the present study was the systematic review, as it allows to identify and synthesize in a standardized and reliable manner the literature on specific topics (16). The search was performed in November 2015 in the Virtual Health Library (BVS), EBSCO, Emerald, ProQuest, Science Direct and Web of Science databases. The search applied the descriptors "efficiency" and "indicators" combined with "organ donation" or "organ transplantation", written

in Portuguese and in English. We included academic articles published in indexed journals, with abstract and full text available in Portuguese, English or Spanish. There was no restriction on the year of publication, resulting in articles published between 1992 and 2014.

Figure 1. Selection of studies included in the systematic review



Source: Developed by authors

As seen in Figure 1, the search returned 344 articles, whose bibliographic references and basic information (authors, year and journal of publication, title, keywords, and abstract) were exported through *EndNote* software to a *Microsoft Excel* spreadsheet. Of the 344 articles returned, 138 duplicates were excluded, 100 of them focusing on clinical aspects, 73 on non-managerial aspects and eight articles that did not use performance indicators. The remaining 25 articles were independently analyzed by two of the authors (MMS and CAA). Of these 25 articles, 23 (92%) were considered adequate for inclusion in the analysis, whist the evaluation of the other two articles

was not consensual. After a discussion by the other authors (BAR and JS), the two articles were removed from the analysis for being deemed as outside the scope of the research.

Information from the 23 included studies (17–39) was extracted from an Excel spreadsheet and grouped into the following categories: study rationale, research objectives, methodology, indicators measured, database, research country, data source and unit of analysis. The indicators were organized according to its focus on the donation stage, on the transplantation stage, or permeating the entire process.

2.3. Results

Concerning the rationale of the targeted literature, most studies (52.2%) presented as research motivation the shortage of organs for transplant and the increase number of patients in the waiting list (20–22, 24, 25, 27–29, 32, 35, 37, 38), whilst 17.4% mentioned the paucity of scientific knowledge and of indicators to measure process efficiency in the ODT field (26, 31, 33, 34). The remaining studies presented diverse motivations, such as the adoption of a new service or donation program in the hospital (13.1%) (18, 19, 23), the search for new ways to evaluate the performance of a transplantation service (8, 7%) (17, 30), the measurement of regional inequalities in terms of number of donations and transplants (4.3%) (36) and the measurement of costs (4.3%) related to ODT activities (39).

Regarding the research objective, 47.8% of the studies aimed to evaluate the functioning of the analyzed units (18, 19, 23, 25, 26, 29, 31, 32, 35–37); 26.1% aimed to present or identify new indicators for donor-transplant activities (17, 24, 30, 33, 34, 38); 21.8% sought to understand the impact of policies, resources and strategies on the donation rates of the unit under analysis (20-22, 28, 29); and 4.3% focused on the effectiveness of resources dedicated to ODT activities (39).

Regarding the research country, 30.4% of studies were performed in the United States (25–27, 29, 31, 32, 38), 17.4% in Brazil (20, 35, 36, 39), 17.4% in Spain (21, 23, 34, 37), 8.7% in Italy (18, 19), 4.3% in the Netherlands (22), 4.3% in Saudi Arabia (24) and 4.3% in 10 western European countries (28). Other studies (13.1%) proposed indicators that could be applied worldwide (17, 30, 33). Overall, the studies investigated the efficiency of donor-transplantation activities at hospitals (52.2%) (18–24, 31.34, 35, 37, 39) or organ procurement organizations (26.1%). (26, 27, 29, 30, 32, 38). The others analyzed nationally aggregated transplant centers (13.1%) (25, 28, 36), or donor programs without location restrictions (8.7%) (17, 33).

On the estimation methods adopted, 60.9% of studies computed the indicators by using a ratio between observed values (17, 18, 20, 23, 24, 25, 27, 30, 33–37, 39), while 39.1% used descriptive statistics, linear programming, and statistical tests that correlate the values of the indicators with factors belonging to the context of operation of the analysis units (19, 21, 22, 26, 28, 29, 31, 32, 38). All articles collected numerical data to compute indicators, with qualitative considerations in parallel to interpret the values found. Regarding data collection, only 39.1% of studies used primary data for the indicators (18, 20, 22-24, 31, 32, 35, 37), while 60.9% used secondary information such as publicly available government health reports (17, 21, 25-30, 33, 34, 36, 38, 39).

2.3.1. Indicators identified in the literature

Within the 23 analyzed studies, 117 indicators used to measure the efficiency in ODT processes were identified. The indicators content was grouped according to the different ODT stages, including activities such as potential donor identification, family interviews, transplant surgery and post-surgery follow-up. As can be seen in tables 1, 2 and 3, respectively, of the total indicators, 71 (60.7%) focus on donation domain, 22 (20.5%) on activities that permeate donation and transplantation stages, and 24 (18.8%) on the demand of organs for transplant and on hospitals' resources related to the ODT activities.

2.4. Discussion

2.4.1. Donation indicators

Unreported brain death is an acknowledged difficulty in the organ donation services, making impossible the detection of many potential donors. Errors may occur due to technical unpreparedness, negligence of professionals, or lack of resources and infrastructure in the hospital to perform tests to confirm brain death in a timely manner (40). At this stage of the process, as shown in Table 1, the indicators depict mortality statistics and records of brain death notifications in the hospitals/ICUs analyzed. These parameters reflect, respectively, the hospital's ability to generate potential donors and the ability to identify such patients. For example, in a hospital with a large history of brain death or severe brain injury, a small number of brain deaths cases may reflect failures to identify and/or report brain death cases. Since unreported notifications represent

loss of potential donors, its estimation can help locating inefficiencies and indicating the need for training of professionals involved in this stage.

However, even after identifying and reporting a potential donor, the inadequate donor maintenance can negatively impact organ supply (40). A single donor in good clinical condition can benefit more than 10 waiting list patients (41) and their clinical maintenance should follow standard procedures conducted by technically prepared intensive care physicians (42). To evaluate this aspect, the selected studies adopted indicators predicting the chance of the patient with confirmed brain death becoming a potential donor and, from there, meeting the clinical criteria to become an actual donor. These indicators may help to identify the number of potential donors lost due to failures such as delays in the brain death diagnosis or inadequate clinical maintenance. As the results of these indicators rely on the health team involved, they may suggest relevant information regarding training gaps (42).

Another key activity in the donation process is the family interview, required for consenting organ donation of deceased donors. Several underlying problems are pointed out in this stage, resulting in low rates of family authorization and the consequent loss of potential donors. They include a lack of knowledge regarding the concept of brain death by family members, dissatisfaction with the medical care provided to the potential donor, and the family interview conducted without following a protocol (43). It is indispensable that healthcare professionals responsible for the family interview possess the necessary technical and interpersonal skills to communicate, clarify doubts and develop empathy with mourning family members. Public policies are also essential to inform and raise awareness of the population on the social relevance and functioning of organ donation services (44, 45).

This activity is portrayed by indicators that seek to measure how many potential donors have been lost due to family non-authorization and to identify families' underlying motivations. In this regard, only one indicator measured families’ satisfaction with the healthcare delivered to the potential donor, as an influencing factor of families consenting rates (17).

As for the donation confirmation stage, after family consent, the largest number of indicators address donors’ characteristics. Such measures give clues on how donations vary across different cultural, demographic or social dimensions. The studies that dealt with this aspect found, for example, that the use of donated organs was significantly associated with the clinical interventions employed (26), but not with the age (26) or race (21, 31) of the donors.

Donation indicators also portrayed the conversion of potential donors into actual donors, and the actual number of donations performed. Measuring this type of indicators is useful once low conversion rates may pinpoint inefficiencies at stages such as the clinical maintenance potential donors (40, 41) and family interview for donation consent (43-45). In turn, analyzing the donations performed is useful for better dimensioning hospital resources required ODT activities (10, 36).

Other measured aspects within this category are the organ non-utilization rates, especially the number of potential donors which donation process was excluded due to medical contraindications. These exclusion criteria, including the presence of contagious diseases and malignant tumors, aim at the safety of the transplant recipient and follow the local legislation at each country (23, 24).

Regarding the logistic aspect of organ donation, each organ has a specific ischemia time for which it can be kept outside the human body (3). Thus, the packaging, storage and transportation from the procurement site to the transplantation site need to respect this interval, which demands synchronization between several professionals (2) and processes (46). The process requires frequent contacts and intense coordination between the hospital where the donation was performed and the hospital where the transplantation surgery will be held, in order to allocate mandatory resources such as ICU beds, equipment and healthcare professionals. Medical staff performing the procurement and transplant surgeries, respectively, also need to be informed about which organs will be procured and recipient's current medical condition. In this regard, efficiency was portrayed by indicators measuring organ utilization - that is, the number of organs that extracted per donor - and logistical aspects, including the time of distribution of procured organs.

Table 1. Grouping of performance indicators related to organ donation activities

Indicator type/category (reference)	No. (%) indicators	Indicator characterization
Mortality Statistics (17, 18-25)	13 (11.1%)	• Total number of deaths, percentage of brain deaths, deaths involving brain injury.
Brain death notification (18, 24)	6 (5.1%)	• Number of brain death notifications; Percentage of notifications documented that generated actual donations.
Potential donors' clinical situation (26, 27)	5 (4.3%)	• Clinical situation of potential donors in terms of ICU length of stay, existence of chronic infections, clinical interventions performed and clinical examinations mandatory for the organ donation.
Nonutilization of donors due to medical contraindications (23, 27)	2 (1.7%)	• Number of potential donors whose donation process is interrupted by medical criteria, due to contagious diseases or malignant tumors.
Attitude towards donation (27)	2 (1.7%)	• Donation rates and family consent rates throughout different cultures, races or geographic locations.
Family consent to organ donation (18-21, 23)	6 (5.1%)	• Percentage of family refusals of total donation consent requests.
Conversion rate (18-20, 23, 28, 29)	6 (5.1%)	• Conversion rate of potential donors into actual donors.
Actual donations (23, 26, 27, 30)	7 (5.9%)	• Annual number of actual donors (measured in absolute value, per million of population or by every 1,000 deaths).
Donors characteristics (11, 26, 27, 31)	10 (8.5%)	• Donor characterization by age group, race, geographical location, cause of death, blood type, medical history, etc.

Organ procurement rates (23, 31-34)	12 (10.2%)	• Number of organs procured per donor (measured in absolute value, per million of population, per deceased donor, per 1,000 deaths, or per clinical intervention performed on the deceased donor).
Logistics involving the distribution of procured organs (17, 35)	2 (1,7%)	• Time between organ removal and its arrival at the transplant site.

**Total number of indicators regarding to donation activities: 71.*

Source: Developed by authors.

Table 2. Grouping of performance indicators related to organ transplantation activities

Indicator type/category (reference)	No. (%) indicators	Indicator characterization
Transplant Indexes (33, 34, 36, 37)	5 (4.2%)	• Number of transplanted organs (per valid donor, per million of population or as a percentage of total organs extracted).
Clinical aspects of donated organs and of recipients (17, 27, 35)	10 (8.5%)	• Perfusion time and morphological changes in the organ; Risk of graft failure; Surgical risk to the recipient; MELD score to assess receiver health severity; Incidence and causes of organ contamination; Decontamination efficiency.
Organ loss (18, 23)	3 (2.5%)	• Causes for non-transplantation of donated organs, including organ loss due to inadequate medication use and maintenance failure.
Resources for Transplant Surgery (17, 36)	3 (2.5%)	• Number of transplants performed in relation to the number of transplantation teams and the number of patients in the hospital or ICU; Amounts spent on transplant surgery, including exams, materials and medications used; Number of days and of wards occupied.

Survival rate after 1 year (37)	1 (0.8%)	• Survival rates of transplant recipients 1 year after surgery.

***Total number of indicators regarding to transplantation activities: 22.*

Source: Developed by authors.

Table 3. Grouping of performance indicators related to organ demand and hospital resources involved in the process

Indicator type/category (reference)	No. (%) indicators	Indicator characterization
Waiting time (17, 23)	2 (1.7%)	• Average waiting time for transplantation.
Estimation of donors (28, 38)	3 (2.5%)	• Historical data, such as national donation rates, and mortality rates from stroke and traffic accidents (which represent the leading causes of brain death), to predict the number of donors (actual and potential).
Dimensioning transplants demand (36)	2 (1.7%)	• Number of transplants performed relative to the population size
Structural characteristics (21, 22, 32)	8 (6.8%)	• They portray the existence - in the hospital, ICU or organ procurement organization - of a neurosurgery specialized unit, of internal donation policies, the use of family interview techniques, of written policies and positions for organ donation activities, among others.
Resources for donation-transplantation (21, 26, 27, 39)	9 (7.6%)	• They depict drugs, tests, materials and beds occupied for the identification and maintenance of a donor and his transplant surgery.

****Total number of indicators regarding to organ demand and hospital resources: 24.*

Source: Developed by authors.

However, among the 117 indicators identified in the targeted literature, only a few portrayed the complex logistic dimension on ODT process. As a consequence, problems such as the proportion of donated organs lost due to delays in the distribution process, were not estimated. Logistic measures could reveal inefficiencies and signal the need for staff training, transport infrastructure investments, as well as the adoption of standardized organ storage and transportation practices.

2.4.2. Transplant indicators

For organ procurement and transplantation procedures, resources such as medical teams, operating rooms, surgical materials and equipment are necessary (47). In general, the indicators in this regard portrayed the number of transplants performed and the clinical aspects of donated organs and of transplant recipients. The characteristics of recipients, donors and donated organs may help the medical team to predict the chances of success in transplant surgeries and post-transplant survival (3, 43). In turn, the transplant index allows comparing the number of procured and transplanted organs, so as to pointing out the possible reasons for non-utilization - either by medical criteria or subjectivities in the decision-making process (3).

Other indicators in this category refer to the number of organs lost, which can result from factors such as medical contraindications, inappropriate medical procedures, family refusal, or failure to detect donors (18, 23). Thus, the investigation of the causes behind this measure is useful to identify inefficiencies such as lack of professional training and scarcity of physical and material resources (3, 36). In turn, the indicators that portray the resources dedicated to transplant surgery (2.56%) can assist in the correct dimensioning of the transplantation capacity of the hospital/ICU.

Finally, although the benefits of organ transplantation as a therapeutic option have already been established in the literature, patient follow-up after transplantation is essential to ascertain the success of the procedure (2). In this regard, only one of the 117 indicators portrayed the survival rate after transplantation, signaling information gaps in this regard. More specifically, the indicator measured the survival rate of transplant recipients 1 year after surgery (37).

2.4.3. Indicators of organ demand and of hospital resources applied in the process

Regarding the structure for the allocation of donated organs for patients in the waiting list, it is essential that the compatibility criteria provided in the legislation follow ethical and legal

principles and that they are known and met in a systematic and transparent manner (44, 45, 48-50). The lack of credibility of the population in the national transplantation system can negatively affect family consent and donation rates (3). Ensuring proper organ allocation involves obtaining and cross-checking information on both donors and patients on the waiting list, with thorough compatibility inquiries prior to the final recipient selection (51). For these activities to occur in a timely manner, it is important to use a reliable information system (43).

In this regard, the analyzed studies used indicators of transplant waiting times and of sizing the demand for organs. The first measure reveals the extent of the mismatch between organ supply and demand, while the second one helps to scale resources to meet the estimated demand. Indicators were also used to estimate the number of effective donors, which can help health managers to plan the care for patients in the waiting-list and to allocate resources needed to operationalize future donor-transplant activities.

Some characteristics and resources of health units can influence the efficiency of ODT processes, such as the availability, in adequate quantity, of beds, equipment and professionals (3). In this regard, the indicators portrayed the dedicated resources for donation and transplantation (7.69%) and the structural characteristics (6.84%) of the health units performing these services. The availability and allocation of dedicated resources to ODT activities may suggest the degree of importance given by the top-management of a given healthcare provider to these services (32). They can be useful in analyzing resources invested versus results obtained by the health units, as well as benchmarking it with other units performing ODT, aiming identify successful practices that may be replicated (36). Because they refer to health units where both donors and recipients may be treated, these indicators impact both the donation and transplantation processes.

2.4.4. Gaps in the efficiency study of organ donation-transplantation processes

The results suggest that publications addressing performance indicators on ODT processes are relatively recent, starting in the nineties, and are in reduced numbers. There is a clear concentration of studies published in the United States, Brazil and Spain, which is apprehensible, since these countries possess international relevance for their transplantation programs. This also indicates that research on this topic is still incipient in most countries. At large, the efficiency is assessed through ratio indicators that vary significantly among studies, both in content and shape.

The measures focus predominantly on the donation stage, suggesting gaps in measuring efficiency in transplant-related activities.

Complex issues that can impact the supply of organs, such as logistical aspects, the population attitude towards organ donation, underreporting of brain death by healthcare professionals, as well as the causes of family non-consent for organ donation or underlying cause for non-utilization of donated organs were poorly addressed. There are also few quality indicators to measure the performance of ODT programs or services, such as the monitoring of preestablished goals in the health units under evaluation (52, 53).

None of the 117 indicators identified regarded the training and skills of healthcare professionals on crucial functions such as brain death identification and notification, or the awareness of these professionals about their role on donation and transplantation results. No indicators were found on training initiatives towards family interviews, aiming at greater safety and effectiveness in the donation processes (42). Likewise, no indicator tracked changes in the number of brain death notification and of family consents for donation before and after the adoption of a given training program. Another aspect not measured in the indicators is the number of potential donors lost due to humans' errors such as delays in identifying and reporting brain death. Measuring these aspects is critical to address evitable human errors that may reduce organ losses and expand the conversion of potential donors into actual donors.

Another relevant issue is that few studies correlated the indicators results with institutional factors (internal to the unit of analysis, such as the hospital size and patient mix) or contextual factors (external to the unit of analysis, as the cultural, social and economic aspects where the hospital is located) that may impact the process measured and help to explain, at least in part, the numbers obtained (54-56).

Important aspects at the end of the ODT process were also scarcely regarded such as organ distribution activities and survival after transplantation surgery. Despite representing the expected benefits of the ODT process, patients' follow-up after surgery, including quality of life, adherence to medical treatment and morbidity rates, were not addressed by the indicators. These gaps point out the need to adopt more and new performance indicators focused on the post-transplant stage.

One more challenge refers to the validation and standardization of the measures adopted, so that they can be used to effectively depict the ODT process and help improve it through the benchmarking of results and successful practices (57). Given the large number and heterogeneity

of indicators found in the literature (n = 117), many of them without detailed procedures regarding their choice, validation and interpretation, it is important to define which ones are best suited to aid the activities of procurement and transplant centers (17).

It is important to note that none of the analyzed studies assessed the quality of indicators used to measure the performance of ODT services. To achieve its potential benefits, an indicator needs to have certain attributes, namely: a) to have a clear definition and standard measurement format; b) to be valid, that is, dependable of the phenomenon it intends to measure; c) to use accessible and quantifiable information; d) to be viable in terms of the time and resources required; e) to be comprehensible for the professionals responsible for its data collection, processing and interpretation, f) to be easily communicable and reasonable for its users target audience (63-67).

As most articles use secondary data to compute indicators, it is also important to consider data check for reliability issues, since the collection and treatment procedures employed cannot be appreciated, requiring confidence in the accuracy of the information provided by the original source. For the primary data, standardized procedures of data collection, treatment, organization and analysis are also valid (58, 59).

To meet a growing information demand, health organizations are increasingly investing on information systems, which comprises the acquisition of technology platforms and the training of those professional responsible for choosing and operationalizing indicators. But in scenarios of limited resources and high public health costs, some authors advocate quality over quantity by replacing a myriad of unreliable indicators with a smaller set of strategic indicators that can be closely monitored (66; 68- 69).

For greater practical utility, indicators need the adhesion of all involved players and the organizational management support. This means to be seen, by health managers and practitioners, as a work tool that provides a common language for performance assessment and continuous improvement of results (70). This happens because, as any other managerial tool, indicators are part of a broad organizational framework. They encompass simultaneous stages of defining the scope of measurement, specifying the objectives and desired performance standards, acquiring and allocating the human and material resources necessary for their measurement and follow-up monitoring, providing feedback to the actors using the indicators information, making necessary methodological adjustments over time, and, finally, putting into practice corrective actions or strategies based on indicators information (61-62).

2.5. Concluding remarks

This study contributed to organize and expand the knowledge on ODT performance indicators, as reported in studies published in relevant management and health academic databases. The authors sought to include all references relevant to the object of study, adopting a systematic, replicable and transparent search process. This effort allowed the identification of aspects barely investigated within the subject, showed the diversity of existing indicators and measures, and clarified the need for new indicators to monitor and improve the ODT process.

The results indicated a lack of uniformity to measure efficiency in ODT activities, as well as the predominance of indicators focused on the donation stage. The potentiality of grouping and comprehensively evaluating these measures lies in its focus on efficiency management, a theme scarcely explored in this literature, as well as in the future application of the indicators in a more effective way. That is, to follow standardization, validation, evaluation and monitoring criteria in order to enable performance measurement, identification of inefficiencies and correction actions to improve the targeted process.

Regardless of its contributions, it is important to cite the study limitations. As with any systematic review, there is inevitable loss of indexed studies in databases not included. Another limitation refers to the diversity of research questions and methodological designs that the authors had to deal with, making the combination of studies susceptible to problems such as the removal of important contextual information. Finally, this paper focused solely on articles published in academic journals, excluding dissertations, theses and government documents. It is recommended that future studies broaden the search scope to include other types of documents.

Increasing the knowledge on indicators of ODT processes may lead to the choice of effective and uniform methods for measuring its efficiency in a given geographic region, allowing the comparison of results across cities, states or countries, as well as observing successful practices that could be replicated globally. Ultimately, research on this topic may help design effective public policies for managing ODT activities, reducing waste and increasing population access to organ transplantation.

Conflicts of Interest.

The authors declared that there is no conflict of interest.

Statement of Responsibility.

Responsibility for the opinions expressed in this manuscript rests strictly with the authors and does not necessarily reflect the opinions or policies of PAJPH or PAHO.

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3. SECOND ARTICLE - Efficiency of Brazilian public services of kidney transplantation: Benchmarking Brazilian states via data envelopment analysis

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Abstract

The Brazilian Public Health System, facing a national economic and political crisis, operates with tight budgets and poor physical infrastructure. Among the services it delivers, organ transplantation represents a complex process wherein inefficient resource allocation is a relevant issue. This study examines the technical and scale efficiency of the Brazilian public services in kidney transplantation, assessing the conversion of physical and labor inputs into kidney transplants using data envelopment analysis. This longitudinal analysis used a secondary database from the Brazilian Registry of Transplants having, as a unit of analysis, 23 Brazilian states that performed kidney transplants from 2013 to 2015. The Malmquist index is applied to examine productivity changes. Data were adjusted per million of population, and factors were extracted by principal component analysis. The results indicate that most states operate in a technically inefficient manner, resulting in a low mean efficiency score. Overall efficiency worsened during the analyzed period, and there was a significant disparity in performance between states, with higher scores in the South and Southeast—the most developed and wealthiest regions—than in the North and Northeast. The results provide managerial insights into the delivery of organ transplantation by the Brazilian public services on both the national and state levels, helping to identify opportunities for better resource allocation in this activity. Given the scarcity of studies that systematically assess and benchmark organ donation and transplantation, this work represents

an innovative context of application and may be useful for the community of relevant policymakers, academics, and health professionals.

Keywords
Brazilian health system; data envelopment analysis; efficiency assessment; kidney transplant.

3.1. Introduction

End-stage renal disease is a serious public health issue in which patient survival depends on renal transplantation or renal replacement therapy, such as dialysis.1 In the long term, however, kidney transplantation is generally more effective than dialysis in public health system costs and patient quality of life.[2-5]

In Brazil, dialysis is the predominant therapy for the increasing number of cases of end-stage renal disease.[6,7] From 2010 to 2014, the number of patients on dialysis increased from 92,000 to 112,000, with the Brazilian Public Health System (SUS) financing approximately 85% of treatments.8 Brazil is also 1 of the most active countries in absolute numbers of transplanted organs, with an increasing number of transplants. Its health sector requires substantial public investment, because SUS fully funds more than 90% of transplants performed nationwide.[9]

Kidney transplantation from deceased donors is the most common mode of solid organ transplantation and requires confirmation of brain death diagnosis and family consent. In 2016, the estimated population needing kidney transplants exceeded the number performed by 45%.[9] Other challenges include the poor infrastructure of public hospitals, crowded intensive care units (ICUs), broken equipment, insufficient health care professionals, and delays in laboratory tests.[9-11] In addition, the sector faces an increased demand for SUS services12-14 and a tight federal health budget.[15] Lastly, the size of Brazil's territory amplifies managerial complexity, with demographic and socioeconomic disparities across states reflected in contrasting availabilities of health resources.[2,16,17] Such a context highlights the importance of assessing how scarce public resources are allocated.

In this context, the present study uses data envelopment analysis (DEA) to estimate the technical and scale efficiency (SE) of Brazilian states for kidney transplants performed by SUS from 2013 to 2015. Its general objective is to rank Brazilian states by their technical efficiency scores and identify those operating at an optimal, oversized or undersized scale. Two secondary

objectives are to identify states with input idle capacity and to report productivity changes during the period of analysis.

Data envelopment analysis is a mathematical method that compares decision making units (DMUs) with similar production processes—units using the same type of inputs to generate analogous outputs, albeit in different amounts.[18,19] The method uses a benchmarking approach that specifies for each inefficient unit an efficient peer as a managerial reference.

In contrast to the numerous efficiency studies in other health care fields—mainly using nonparametric methods such as DEA [20-23]—the literature for organ donation and transplantation (ODT) services remains sparse. A recent systematic review of the literature in health and management databases revealed that the efficiency of ODT activities is mostly assessed using indicators—ratios of a single input to a single output—and identified only [3] applications of DEA.[24] These 3 studies used the number of organs transplanted as the output and expenses related to physical and human resources as the inputs.[25-27] In a field tangential to kidney transplantation, DEA has also been applied to evaluate the efficiency of dialysis centers in the United States, including market and facility factors that impact dialysis outputs.[28,29]

Given this potential gap in the literature regarding the use of mathematical or statistical methods to assess the efficiency of ODT activities, this study enriches this scarce literature and intends to stimulate new empirical applications and debates on the theme. In addition to their academic relevance in the ODT field, benchmarking approaches like DEA are useful for health managers, practitioners, and policy makers to identify and disseminate successful management practices.[30] The focus on improvement through better resource allocation is especially important in countries with intense socioeconomic heterogeneity among states and regions, such as Brazil. A systematic method for comparing Brazilian states is thus useful for prioritizing activities, resources, and locations that require the greatest attention from health authorities. Moreover, the benchmark approach highlights the importance of information sharing and unified procedures for performance measurement.

The paper is organized as follows: Section 2 contextualizes the Brazilian public health system and the multifold factors underlying its ODT services. Section 3 presents a brief description of the sample, database, input/output variables, and methodology used to assess efficiency. Sections 4 and 5 detail the results and principal concluding remarks.

3.2. Overview of the Brazilian health care system and its organ transplantation services

Established in 1988, SUS is guided by principles of universality and equity, in which all Brazilian citizens have an equal right to free health procedures and services. Examples of the broad range of services covered include medical appointments, laboratory tests, surgery and hospitalization related to donation, and the allocation and transplantation of organs. The system's funding comes from federal, state, and municipal governments. Following the guidelines of managerial decentralization (Law 8080), each Brazilian state has the autonomy to plan its health resources and must apply at least 12% of its annual tax revenue to health.

The Brazilian Unified Health System's current expenditure surpass R$400 billion, representing about 8% of national gross domestic product (GDP).[12] However, the system faces critical issues such as low health care access and insufficient action on preventative health.[31-33] Even with expenditure comparable to several other Latin American countries with similar GDP per capita, Brazilian health care spending is below many European countries with similar proposals for public health. Some specialists argue that the current level of public spending is incompatible with the universal SUS model.[15,34]

Another controversial issue is that, despite the great disparity in socioeconomic development levels, transfers from the federal health budget to the states do not account for such inequalities.[31,35] Per capita income among states, for example, varies from R$2351.00 in the Distrito Federal to R$575.00 in the state of Maranhão. Disparities also refer to factors such as access to education, basic sanitation, and life expectancy.[12] This results in great differences in health outcomes between geographic areas, with smaller states struggling to meet health demands in proportion to their financial resources and an intense flow of patients seeking better treatments at more developed health centers in different cities and states.[36]

Along with health care funding, efficiency of resource allocation is a fundamental issue for SUS. According to the 2010 world health report, inefficiency is responsible for wasting 20% to 40% of all global health spending, and the numbers are even worse for underdeveloped or developing countries such as Brazil.[34] Besides operating within tight budgets and the large health demands because of increasing life expectancy and chronic disease,[12] Brazil's ongoing political and economic crisis[14] has placed pressure on SUS. The public health system accommodates millions of unemployed clients who have lost access to private health plans.[13] Moreover, the waste and misuse of public health resources is an old problem driven by the large amounts of public

investment, information asymmetry among patients and health professionals, and the great power concentrated in some stakeholders such as large pharmaceutical companies. [37] In such a scenario, this assessment of Brazilian SUS services represents an initial effort to improve resource efficiency in this vital sector.

This study focus on ODT, an area within SUS of great social relevance for saving and improving the quality of life of many patients, and 1 of continuous increase in the number of procedures performed and of medical developments.[38] Organ transplants began in Brazil in the 1960s, becoming more important 15 years later with the development of surgical techniques and immunosuppressive drugs. The following decades marked the intense regulation and national organization of such procedures, resulting in the creation of the National Transplant System in 1997. Brazil has since performed an increasing number of transplants.[39]

The number of solid organ transplant surgeries increased 46% in the last 8 years, from 5428 in 2008 to 7955 in 2016. Brazil is currently the second-most active country in the absolute number of transplants, behind United States.[9] In 2013, public health expenses for ODT procedures and services totaled R$1.4 billion, 17% more than the previous year. In 2012, the government also introduced incentives for hospitals which perform transplants, with SUS reimbursements exceeding the cost of the procedures, and higher percentages of reimbursement for hospitals performing several types of transplant.[40] Nevertheless, the estimated availability of solid organs is significantly less than the number of transplants performed.[9] This results in long waiting lists and patients who die or who are removed from the transplant queue because of a deterioration in their clinical status.[41]

Another striking feature of ODT processes is their complexity, involving multidisciplinary professionals and organizations who make simultaneous and timely decisions. The health team includes neurologists, intensive care specialists, hospital coordinators, transplantation surgical teams, nurses, and psychologists. The process begins with joint work by organ procurement organizations (OPOs) and medical teams to identify potential donors at hospitals and diagnose brain death through clinical and laboratory tests. If confirmed, the brain death is communicated to the potential donor's family and the State Transplant Center. The OPO and medical team then interview the family to provide support and request organ donation authorization. If the family authorizes the organ donation, the State Transplant Center is informed which organs will be transplanted and their clinical condition. Immunological tests are performed on the next patient in

the transplant queue, and a transplant center and surgical team is notified of the procedure date. Finally, after the removal of donated organs, the donor's body returns to the family and the organs are transported to the center where the transplant surgery will be performed.[10]

In addition to the logistical complexity and the high rate of family refusals to donate organs (around 46% in 2016), the unavailability of ICU beds and equipment for brain death diagnosis, and delays in laboratory tests, in the allocation of medical teams for transplant surgery and in organ transportation frustrate the promptness required in the process.[42] All these factors reinforce the importance of management to this field.

When discussing public health, it is important to acknowledge that services occur in the socioeconomic context in which the system, the health users, and the health providers are situated.[43,44] Living conditions—including education, income, and basic sanitation—can shape a population's use of and relationship to public health services.[45,46]

The performance of ODT underlies not only the quantitative aspects of resource availability and allocation but also the qualitative aspects,[47] such as the hospital culture in which the service takes place. Within hospitals, the institutional importance given to ODT activities depends on the board of directors and the management practices regarding, for example, the training and remuneration of ODT professionals. The tasks performed by these professionals pervade all stages of ODT activity, from contact with families to the identification of brain death and medical support to potential donors.

Many studies have examined the importance of a positive attitude by ODT professionals, such as physicians and nurses, towards organ donation.[24,48-50] These professionals are potential opinion leaders, able to inform, clarify, and stimulate the health system's users to discuss organ donation with family and friends. However, proper remuneration and training seem necessary for developing ODT advocates.[17,51-53]

ODT operations require the willingness of the general population to donate. This willingness is hampered by a lack of public understanding of ODT processes and scarce public discussion about organ donation and its relevance.[54-56] Educational policies aimed at decreasing family refusal are essential because most transplants in Brazil come from deceased donors and, by law, donations rely on family consent. As constantly advocated in the literature, education is a fundamental tool for increasing the individual autonomy for making conscious decisions, improving awareness,

building a generally positive attitude regarding ODT, and aiding choices about organ donation.[17,51,57-62]

It is worth noting that a family's decision about organ donation occurs while they are mourning the loss of a loved one, often without previous thought on the matter.[54] Other aggravating factors are dissatisfaction with the care received by the patient, the distrust of the National Transplant System organ allocation system, and the unfamiliarity with the concept of brain death, frequently resulting in insecurity about the diagnosis of death and the irreversibility of this clinical status.[17,51,56-59,63,64] The doubts prevail when the health team fails to apply the technical knowledge and interpersonal abilities required to provide informed support and create an empathetic connection with the family during the organ donation interview.[17,54,59]

An examination of the productiveness of Brazil's ODT processes is an important step to understanding this public service. However, it is also important to examine the complexity of the sector and the variety of issues that underlie technical considerations. As well as the infrastructure provided by SUS and resource management at state and hospital levels, government efforts should accommodate the heterogeneity of Brazil's states and acknowledge the importance of broader socioeconomic spheres such as public health education and the continuous training of health professionals.

3.3. Methods

Data envelopment analysis relative efficiency scores are computed by comparing each DMU with the remaining units in the sample, according to their capacity to generate greater outputs with minimum input consumption. The units deemed technically efficient represent waste-free productive processes, with no room for improvement in resource allocation. The reduction of an input would thus result in decreased output(s) or increased consumption of another input. Likewise, an increase in an output would result in increased input(s) or reduction of other output(s).[65-67]

Scores equal to 1 denote technically efficient units, whereas scores greater than 0 and less than 1 designate inefficient units. The scores represent the extent to which inputs can be reduced while maintaining constant output levels (input-oriented model) or the extent to which outputs may be maximized while maintaining constant input levels (output-oriented model).[19,65,66]

There is no consensus on the most appropriate orientation of ODT processes. However, public health services focus on patient well-being, often by increasing the quantity and quality of the health care services provided to the population.[68] Following this logic, and in line with previous applications of DEA in the ODT literature,[25-27] the efficiency model in this study is output oriented. The linear programming description of the output-oriented model that was applied is described below. Consider n DMUs, where each DMU_j (j = 1,...n) uses m inputs to generate s outputs. The xij and yrj nomenclatures represent respectively the ith input and the rth output in the DMU_j, while DMU_0 represents 1 of the units analyzed.

$$\text{Max } \theta + \varepsilon \left(\sum_{i=1}^{m} S_i^- + \sum_{r=1}^{s} S_r^+\right)$$

$$\sum_{j=1}^{m} \alpha_j \; x_{ij} + S_i^- = x_{ijo} \qquad \forall I$$

$$\sum_{j=1}^{n} \alpha_j \; y_{rj} - S_r^+ = h_{jo}\, y_{rjo} \qquad \forall r$$

$$\alpha_j \geq 0, \forall j$$

$$Add \sum_{j=1}^{n} \alpha_j = 1$$

In this representation, ε is a non-Archimedean infinitesimal while S_i^- and S_r^+ represent the input and output slacks respectively. In turn, α_j and θ are parameters to be calculated, where α_j is the feasible DMU_j production set and $1/\theta$ is the technical efficiency of the DMU_{j0}.

Another important DEA specification is the type of returns to scale; that is, constant returns to scale (CRS) or variable returns to scale (VRS). CRS models assume that the size of the operation has no impact on DMU performance, since an increase in input would lead to a proportional increase in output. By contrast, VRS models assume that an increase in input may be accompanied by a greater than proportional (increasing returns to scale, IRS) or less than proportional (decreasing returns to scale, DRS) increase in output. [65,66,69,70]

The impact of scale on efficiency is measured by SE, defined as the ratio of technical efficiency (estimated by CRS models) and pure technical efficiency (calculated by VRS

models).[65,66,69,70] An SE equal to 1 signals a DMU operating at an optimum scale size, whereas an SE greater than 0 and less than 1 indicates scale inefficiency, which can be determined by the sum of the weights in the CRS model specifications. [71] Many conditions related to market competition, budget limitations and regulatory aspects might lead a healthcare organization to operate at an inefficient operational size, with economies or diseconomies of scale.[72] Consequently, the present study employs a VRS DEA model, in addition to presenting the CRS results, which represent more conservative estimates than the former.

As well as considering the impact of scale on performance, DEA permits the use of multiple inputs and outputs, and is thus better suited to portraying the complexity of healthcare productive processes. [23, 73] Another distinguishing aspect is that DEA does not require explicit assumptions about the form of the production function being analyzed. Only a broad class of functions are fixed *a priori*, and a limited number of parameters are estimated from the data. Thus, the model's structure is sufficiently flexible for the data used and is not excessively reliant on theoretical assumptions, while also minimizing specification problems. [65,74]

DEA also enables the identification, for each DMU, of input slacks, which are resources in excess or with idle capacity that are not generating outputs compatible with the operation scale. [75] Finally, another functionality examined in this study is the identification of efficient pairs for each inefficient DMU that can be used as a reference to improve performance. In this sense, each state could mirror the practices adopted by its peers, accounting for necessary adaptations to local conditions. [76] Efficient units are considered their own benchmark or reference point.

3.3.1. Variables and data source

Secondary data from the Brazilian Registry of Transplants (RBT) (www.abto.org.br) were used to form the input and output variables. Of the 27 states constituting the Brazilian Federation, four were excluded due to missing or inconsistent data, leaving 23 states. The number of DMUs relative to the number of variables complies with the standard established by Cooper, Seiford, and Tone (2007). [77] The states exhibit operational homogeneity: they employ the same types of inputs to produce similar outputs, and managerial autonomy, playing an administrative role in ODT activities, as regulated by the Brazilian Transplant Law 9,434.

Since Brazilian states are quite heterogeneous in their populations, the variables were adjusted per million of population (pmp). The following inputs were employed: the number of

medical teams performing kidney transplant surgery; the number of organ procurement organizations (OPOs); the number of ICU beds; and the number of effective donors. The output measure was the number of kidney transplants from deceased donors. The criteria for the selection of variables were observed data availability and previous DEA applications in the ODT literature. [25-27] The selection of the variables also included a qualitative stage in which coordinators of the Rio de Janeiro and Santa Catarina transplant programs were approached. These Brazilian experts on the management and medical practice of ODT permitted a better understanding of the context and underlying variables in the provision of this health service.

The input and output variables aimed to describe the operations of the DMUs in the provision of the public services of kidney donation and transplantation. The transplant teams and organ procurement units represent human and institutional resources located in the hospital environment, including health professionals such as physicians, nurses, social workers and psychologists. These inputs enable services such as transplant surgery, the registration of potential donors, reporting of brain death notifications, communication with the donor family, and the logistical distribution of organs within the area of operation.

The ICU beds represent the physical infrastructure necessary for the identification and maintenance of deceased donors. [17, 78] These patients require devices for the artificial maintenance of breathing and hemodynamic functions that prevent heart failure and other complications that would hinder organ donation. ICU bed availability is thus essential to minimizing avoidable loss of potential donors and increasing the number of brain death notifications. [79] Similarly, effective donors represent a necessary input for transplants to occur. This variable is reflected by the number of brain death notifications minus the number of potential donors lost due to factors such as medical contraindications, family refusal, and maintenance failure. [26, 80-83]

In turn, the number of kidney transplants performed in each state represents the final and primary objective of the public health services of kidney donation and transplantation. [25, 26, 84] The transplants performed (output variable) are linked to the presence of adequate quantities of inputs (human, physical and materials resources).

3.3.2. Variable reduction

The discrimination capability of DEA models is impacted by the number of inputs, outputs and DMUs adopted. A higher number of variables compared to the number of DMUs indicates a

lower power of differentiation between efficient and non-efficient units. [85-87] Additionally, the maintenance of highly correlated input or output variables adversely affects the model's robustness. [88,89]

In this study, given the high values of correlation between inputs, principal component analysis (PCA) was applied to determine the most relevant input combinations using factor extraction, as proposed by Adler and Berechman (2001). [87] Factors were extracted from the input variables by PCA-DEA with Varimax rotation. The categorization was based on items with factor loadings higher than 0.50 [90] and eigenvalues greater than 1.

As shown in Table 1, two factors explained 82% of the total variance in the data. The technique proved appropriate for the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and the Bartlett sphericity test, rejecting the null hypothesis that the correlation matrix was an identity matrix at a significance level of 5%. After variable reduction, the 'Transplant Teams' and 'Organ Procurement Units' inputs constituted the 'Staff Index', representing the human and institutional resources responsible for organ retrieval and transplantation activities. The 'Effective Donors' and 'ICU Beds' inputs constituted the 'Capacity Index', which represents the transplant capabilities of the healthcare facility based on the available quantities of these variables.

Table 1. Factor Extraction via Principal Component Analysis

	Year					
	2013		**2014**		**2015**	
Inputs' index for variable reduction	**Staff**	**Capacity**	**Staff**	**Capacity**	**Staff**	**Capacity**
Transplant teams	**0.93**	0.3	**0.93**	0.04	**0.85**	0.33
Organ procurement units	**0.92**	0.04	**0.9**	0.1	**0.93**	0.04
ICU beds	0.45	**0.73**	0.25	**0.85**	0.09	**0.89**
Effective donors	0.42	**0.79**	0.41	**0.79**	0.24	**0.84**
KMO adjustment factor	0.68		0.65		0.61	
% of variance explained	0.818		0.818		0.819	
Approx. chi-square	25.45		24.28		24.17	
Degrees of freedom	6		6		6	
p-value sig.	0.000		0.000		0.000	

Abbreviation: ICU, Intensive Care Unit; KMO, Kaiser-Meyer-Olkin

3.3.3. Malmquist Index

To measure variations in DMU productivity between two consecutive time periods (*t* and *t* + 1), this study adopted the Malmquist Index, as designed by Färe et al. (1994). [91] An index greater than 1 indicates progress, whereas an index less than 1 indicates retrogression, and an index equal to 1 indicates no changes in the total productivity factor of the DMU. [67,77] This approach allows the identification of which states had stagnant, increased or decreased productivity levels for a consecutive period, also enabling the examination of possible causes and resolutions for these performance changes. [92]

The Malmquist Index is widely used in benchmarking studies and also displays the nature of productivity change regarding two distinct effects or behaviors. A catch-up effect occurs when the DMU approaches or departs from the efficient frontier through increases or decreases in its technical efficiency. The frontier-shift effect occurs when the sector to which the DMU belongs undergoes changes that, as a whole, lead to advances in productivity over two consecutive periods. These sector changes may include managerial, legal, administrative or technological innovations. [77]

Given an input *x* and an input *y* in the periods *t* and *t*+1, (x^{t+1}, y^{t+1}) *e* $(x^{t},\ y^{t})$ represent the efficiency scores, while D_P^t represent the distance function of a reference technology in the period *t.* The productivity change problem is estimated in the distance function (1), while the change of total productivity factor measured by Malmquist Index is specified in the equation (2).

$$(1)\ \text{Total productivity Factor} = \frac{D_P^t\ (\mathrm{x^{t+1}},\mathrm{y^{t+1}})}{D_P^t(\mathrm{x^t},\mathrm{y^t})}$$

$$(2)\ \text{Frontier-shift effect} = \left[\frac{D_P^t(\mathrm{x^t},\mathrm{y^t})}{D_P^{t+1}(\mathrm{x^t},\mathrm{y^t})}\ \mathrm{x}\ \frac{D_P^t\ (\mathrm{x^{t+1}},\mathrm{y^{t+1}})}{D_P^{t+1}\ (\mathrm{x^{t+1}},\mathrm{y^{t+1}})}\right]^{1/2}$$

3.4. Results

Table 2 presents the descriptive statistics of the inputs and the outputs of the 23 Brazilian states analyzed. Significant differences were observed between the minimum and maximum values of the inputs and the outputs, with significant standard deviation values for all variables. Such asymmetry in distribution signals a disparity in health infrastructure conditions in ODT.

Table 2. Description of Variables (pmp) in DEA and Malmquist Index Analysis

	Year		
	2013	2014	2015
Input: Transplant teams			
Mean	0.588	0.666	0.686
SD	0.377	0.431	0.417
Minimum	0.010	0.010	0.010
Maximum	1.360	1.560	1.560
Input: Organ procurement units			
Mean	2.870	2.897	2.957
SD	2.741	2.603	2.679
Minimum	0.010	0.010	0.010
Maximum	11.380	11.380	11.380
Input: ICU beds			
Mean	166.69	174.31	178.87
SD	81.297	86,979	78.585
Minimum	46.350	88.660	90.500
Maximum	399.980	436.550	414.370
Input: Effective donors			
Mean	10.430	11.226	11.848
SD	7.521	8.735	9.037
Minimum	0.300	0.300	1.100
Maximum	26.400	33.100	32.300
Output: Kidney Transplants			
Mean	15.552	16.482	16.259
SD	12.731	14.978	14.376
Minimum	0.010	0.010	0.010
Maximum	41.170	44.360	45.510

Abbreviation: DEA, Data Envelopment Analysis; SD, Standard Deviation; PMP – per million of population

3.4.1. DEA efficiency scores

Table 3 presents the DEA technical (CRS, VRS) and scale efficiency scores for the most recent year of analysis. The states of Ceará, Rio Grande do Sul and the Distrito Federal were efficient under CRS, whereas the VRS model also identified Acre and Maranhão as efficient units. The mean and median efficiency under VRS were 0.59, indicating that states should have been able to generate outputs using 41% less inputs. A significant number of states presented low efficiency scores in both VRS and CRS models (e.g. Alagoas, Amazonas, Bahia, Goiás, Mato Grosso do Rul, Paraíba, Roraima, Sergipe), indicating that the origin of inefficiencies is not in the

scale of their operation but in structural problems. Other states obtained large differences in scores between the CRS and VRS efficiency models (e.g. Acre, Maranhão, Piauí), demonstrating the effect of scale on their productivities. Finally, some states (e.g. Ceará, Distrito Federal, Rio Grande do Sul) appeared as benchmarking in both models, signaling operation on an ideal scale.

Table 3. DEA efficiency scores by Brazilian states (2015)

Unit of Analysis	CRS	VRS	SE	Lambda Sum	Return to Scale
Acre	0.42	1.00	0.42	0.36	IRS
Alagoas	0.16	0.27	0.59	0.54	IRS
Amapá	0.14	0.22	0.62	0.59	IRS
Bahia	0.17	0.26	0.67	0.58	IRS
Ceará	1.00	1.00	1.00	1.00	CRS
Distrito Federal	1.00	1.00	1.00	1.00	CRS
Espírito Santos	0.52	0.60	0.87	0.72	IRS
Goiás	0.25	0.31	0.82	0.78	IRS
Maranhão	0.18	1.00	0.18	0.35	IRS
Mato Grosso do Sul	0.00	0.00	0.65	0.58	IRS
Minas Gerais	0.56	0.62	0.91	0.82	IRS
Pará	0.24	0.51	0.47	0.46	IRS
Paraíba	0.21	0.38	0.54	0.49	IRS
Paraná	0.56	0.56	0.99	0.98	IRS
Pernambuco	0.81	0.85	0.95	0.92	IRS
Piauí	0.33	0.72	0.45	0.48	IRS
Rio de Janeiro	0.56	0.59	0.95	1.29	DRS
Rio Grande do Norte	0.58	0.69	0.84	0.78	IRS
Rio Grande do Sul	1.00	1.00	1.00	1.00	CRS
Roraima	0.21	0.27	0.80	0.68	IRS
Santa Catarina	0.83	0.93	0.88	1.13	DRS
São Paulo	0.76	0.83	0.91	1.09	DRS
Sergipe	0.01	0.02	0.69	0.59	IRS

Abbreviation: DEA, data envelopment analysis; CRS, constant return to scale; VRS, variable return to scale; SE, scale efficiency; IRS, increasing return to scale; DRS, decreasing return to scale; DMU, decision making units.

Table 4 displays the descriptive statistics of DEA efficiency scores through the period of analysis. The analysis shows a low mean technical efficiency score in both CRS and VRS models, with a decrease in the mean score from 2013 to 2014 and from 2014 to 2015. A maximum of three out of the 23 states were deemed efficient under the CRS model, and only five states under the VRS Model. Considering the Scale Efficiency, the SE scores are higher when compared to CRS

and VRS scores. They presented a slight decrease from 2013 to 2014, followed by a slight increase from 2014 to 2015. The distribution of efficiency scores is also shown graphically in Figure 1.

Table 4. Results of DEA analysis

		2013	2014	2015
CRS	Mean	0.479	0.460	0.456
	Median	0.417	0.406	0.420
	SD	0.322	0.306	0.322
	Efficient DMUs (%)	03 (13.04%)	02 (8.69%)	03 (13.04%)
VRS	Mean	0.690	0.618	0.593
	Median	0.757	0.564	0.598
	SD	0.304	0.312	0.329
	Efficient DMUs (%)	05 (21.74%)	04 (17.39%)	05 (21.74%)
SE	Mean	0.839	0.735	0.748
	Median	0.880	0.776	0.817
	SD	0.576	0.230	0.227
	Efficient DMUs (%)	03 (13.04%)	02 (8.69%)	03 (13.04%)

Abbreviation: DEA, data envelopment analysis; CRS, constant return to scale; VRS, variable return to scale; SE, scale efficiency; DMU, decision making units.

Under CRS—the most conservative model to deem efficient units—almost half of the states (n = 11; 47.8%) had scores below 0.40 from 2013 to 2015. Under the CRS model, five states (21.72%) in 2013–2014 and eight states in 2015 (35%) also presented the lowest range of efficiency scores. Taken together, the results show a significant level of inefficiency in resource allocation and, consequently, much room for improvement.

Of the Brazilian regions in the most recent year of analysis, the South and Southeast had the highest mean scores in both the CRS and VRS models, also exhibiting higher mean efficiency scores than the national average (Table 5). These regions also presented higher SE scores, indicating better sizing of their activities. By contrast, the North and Northeast regions presented the lowest efficiency scores. All states in the South and Southeast regions are in the median to high performance groups (efficiency scores above 0.50, under both CRS and VRS) while the states of the North and Central West (with the exception of the Distrito Federal) and most states of the Northeast are in the worst-performing group (scores below 0.50). The regional highlights (states with the highest scores within their regions) were Distrito Federal, Ceará, Rio Grande do Sul, and São Paulo (respectively in the Midwest, Northeast, South and Southeast regions).

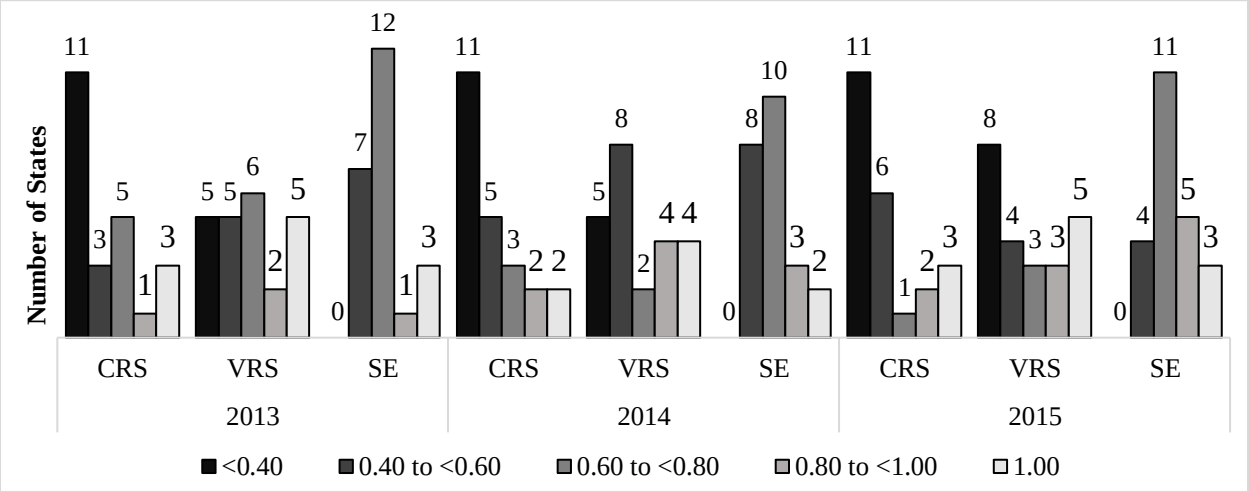
These regional differences are also evident in socioeconomic indicators such as GDP and the human development index, with greater economic development in the South and Southeast regions. The striking differences among Brazilian regions through the period of analysis is displayed graphically in Figure 2.

Table 5. DEA scores by geographic regions (2015)

Region		CRS	VRS	SE
North	Mean	0.253	0.501	0.576
	Median	0.226	0.390	0.542
	SD	0.120	0.356	0.170
Northeast	Mean	0.382	0.576	0.656
	Median	0.209	0.694	0.667
	SD	0.339	0.359	0.257
South	Mean	0.795	0.833	0.959
	Median	0.827	0.935	0.993
	SD	0.222	0.236	0.065
Southeast	Mean	0.600	0.658	0.912
	Median	0.561	0.609	0.910
	SD	0.106	0.113	0.033
Midwest	Mean	0.417	0.436	0.823
	Median	0.251	0.306	0.817
	SD	0.520	0.512	0.174
Brazil	Mean	0.4560	0.5926	0.7480
	Median	0.4209	0.5979	0.8174
	SD	0.3219	0.3292	0.2274

Abbreviation: DEA, data envelopment analysis; CRS, constant return to scale; VRS, variable return to scale; SD, standard deviation.

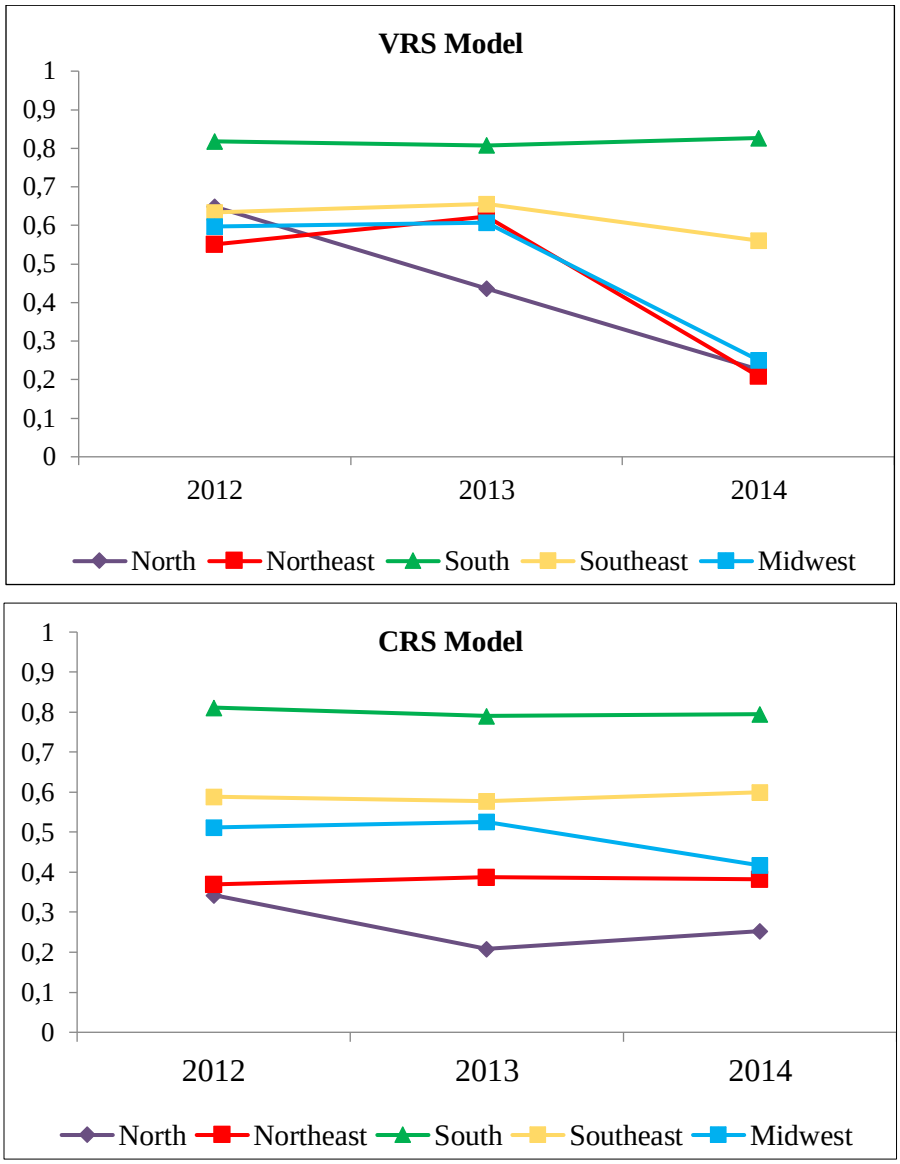
Figure 1. The distribution of efficiency scores



Based on the most recent Brazilian Registry of Transplantation [9] and Brazilian Population Census, [12] it is possible to observe that—with the exception of the Northeast states of Ceará and Pernambuco—the states with the highest efficiency scores are also national leaders in socioeconomic metrics such as the human development index and spending on ODT activities. Santa Catarina, Rio Grande do Sul and São Paulo are also distinguished by their low rates of family refusal for organ donation and high rates of conversion of potential donors into actual organ donations. [9] These characteristics signal a greater public awareness and training of health professionals regarding ODT activities. The best-performing states also have the highest national rates of brain death notification pmp, a measure closely related to the training and motivation of health teams for organ procurement activities.

Although a number of states had low efficiency scores in both the CRS and VRS models, other states exhibited great differences between their CRS and VRS scores, demonstrating the effect of scale on their productivity. Only three states were benchmarks in both models, signaling operation on an ideal scale. Of the remaining 20 states not operating on an optimal production scale, only three (Rio de Janeiro, Santa Catarina and São Paulo) exhibited DRS, indicating possible oversizing of operational structure. By contrast, the other 17 states exhibited IRS, suggesting operation in reduced dimensions. The impact of scale in most Brazilian states is consistent with studies that have related an appropriate volume of operation to better results in ODT centers in terms of productivity, administrative expertise, quality of service, and medical interventions. [3, 93]

Figure 2. The striking differences among Brazilian regions through the period of analysis



3.4.2. Input slack analysis and reference units

As shown in Table 6, the CRS model indicates a greater number of states with idle capacity than the VRS model. From the perspective of CRS, no state showed slacks in the input index composed of ICU beds and effective donors (capacity factor), signaling possible saturation in these variables. This result is consistent with the state of Brazilian hospitals, where a shortage of ICU beds is common. In SUS, ICU beds are used not only for the identification and maintenance of organ donors but also for any patients requiring monitoring and intensive treatment. Additionally, in the national setting of long waiting lists, idle capacity of effective donors could reflect a

significant number of donations that are not converted into transplants due to factors such as human error, lack of hospital infrastructure, medical contraindications or logistical problems.

Table 6. Input slack analysis (2015)

DMU	CRS Model		VRS Model	
	% Slack Staff Index	% Slack Capacity Index	% Slack Staff Index	% Slack Capacity Index
Acre	9.62%	0.00%	0.00%	0.00%
Alagoas	54.84%	0.00%	0.00%	0.00%
Amapá	0.00%	0.00%	0.00%	0.00%
Bahia	24.44%	0.00%	0.00%	0.00%
Ceará	0.00%	0.00%	0.00%	0.00%
Distrito Federal	0.00%	0.00%	0.00%	0.00%
Espírito Santos	6.67%	0.00%	22.15%	0.00%
Goiás	0.00%	0.00%	0.00%	0.00%
Maranhão	5.90%	0.00%	0.00%	0.00%
Mato Grosso do Sul	16.98%	0.00%	0.00%	0.00%
Minas Gerais	21.50%	0.00%	0.00%	0.00%
Pará	16.99%	0.00%	0.00%	0.00%
Paraíba	29.4%	0.00%	0.00%	0.00%
Paraná	26.36%	0.00%	0.00%	0.00%
Pernambuco	0.00%	0.00%	0.00%	0.00%
Piauí	2.10%	0.00%	0.00%	0.00%
Rio de Janeiro	0.00%	0.00%	0.00%	0.00%
Rio Grande do Norte	0.00%	0.00%	0.00%	0.00%
Rio Grande do Sul	0.00%	0.00%	0.00%	0.00%
Roraima	18.59%	0.00%	0.00%	0.00%
Santa Catarina	3.80%	0.00%	14.91%	11.45%
São Paulo	3.64%	0.00%	11.82%	8.65%
Sergipe	12.37%	0.00%	0.00%	0.00%

The slacks are concentrated in the input index comprising transplant teams and organ procurement units (staff index). This finding is consistent with the general scenario of ODT activities, since physical infrastructure and human resources must be available for the maintenance

of potential and effective donors as soon as they are identified in the hospital, to avoid organ loss. The great variability in organ supply results in unpredictable demand on the part of the input variables. The states with more pronounced slack in the staff index (idle capacity of greater than 25%) were Alagoas, Paraiba and Parana, which are located in the Northeast and North regions.

The states of Rio Grande do Sul and Ceará were identified as reference peers in both DEA models, serving as the first benchmarking option for 15 and five inefficient states, respectively, in the CRS model and for three and seven states, respectively, in the VRS model. Thus, to become efficient, inefficient states would have to use a combination of input variables from Ceará and Rio Grande do Sul. However, some options for an optimal mix of inputs may not be feasible in the local reality, and thus state managers must carefully interpret any recommendations.

3.4.3. Malmquist Index

In the VRS model, 52.2% (*n*= 12) and 39.1% (*n* = 9) states exhibited a decrease in technical efficiency scores from 2013 to 2014 and from 2014 to 2015, respectively. Considering the 2013-2015 period, 21.7% (*n* = 5) states presented consecutive reductions in technical efficiency scores. This negative scenario is also evident in the Malmquist Index. As shown in Table 7, from 2013 to 2015 the national mean of the Malmquist Index was 0.978, indicating a retrogression of 2.2%. Almost half of the states (*n* =11; 47.8%) presented a mean Malmquist Index below 1.00 (Table 8).

Table 7. Malmquist index by Brazilian regions

Brazilian Region		Malmquist Index	Catch-up Effect	Frontier-Shift Effect
North	Mean	0.903	0.870	0.984
	Median	0.888	0.936	0.984
	SD	0.506	0.229	0.006
Northeast	Mean	0.896	0.899	1.031
	Median	0.921	0.952	1.008
	SD	0.385	0.239	0.132
South	Mean	0.997	0.992	1.011
	Median	1.031	1.000	1.021
	SD	0.093	0.036	0.027
Southeast	Mean	1.117	1.054	0.996
	Median	1.086	1.041	0.986
	SD	0.159	0.081	0.025
Midwest	Mean	0.975	0.882	1.013

	Median	1.048	1.000	1.002
	SD	0.369	0.322	0.031
Brazil	Mean	0.978	0.939	1.007
	Median	1.032	1.000	0.989
	SD	0.336	0.207	0.083

Abbreviation: SD, standard deviation.

Table 8. Malmquist index by Brazilian states

Brazilian State	Malmquist Index	Catch-up Effect	Frontier-Shift Effect
Acre	1.513	1.039	0.981
Alagoas	1.229	0.876	1.276
Amazonas	0.323	0.560	0.990
Bahia	0.523	0.734	0.965
Ceará	1.059	1.000	1.059
Federal District	1.048	1.000	1.048
Espírito Santo	0.958	0.971	0.980
Goiás	1.301	1.129	1.002
Maranhão	0.837	1.000	0.837
Mato Grosso do Sul	0.575	0.518	0.989
Minas Gerais	1.086	1.052	0.985
Paraná	1.060	1.047	0.987
Paraíba	0.986	1.026	0.961
Pará	0.891	0.952	0.980
Pernambuco	0.921	0.952	1.008
Piauí	0.845	0.924	0.966
Rio de Janeiro	1.338	1.165	0.986
Rio Grande do Norte	1.501	1.216	1.013
Rio Grande do Sul	1.031	1.000	1.031
Roraima	0.716	0.832	0.976
Santa Catarina	1.068	1.023	1.021
São Paulo	1.085	1.029	1.033
Sergipe	0.167	0.362	1.195

This overall decrease in the sample's technical efficiency scores is mainly due to the North and Northeast regions. The South and Central West regions exhibited productivity close to 1.00, and the Southeast region exhibited productivity progress of 11.7% in the period. By contrast, the North and Northeast regions presented productivity indexes lower than the national average.

More specifically, nine states (39.1%) presented values of less than 1 for the catch-up effect, signaling problems in the diffusion of successful management practices (such as the prioritization of technical expertise in human resources and well-defined policies for investment planning). In addition, 13 states (56.5%) presented values of less than 1 for the frontier-shift effect related to the application of new technologies in the DMU's operational activities. Such technologies allow, for example, improved integration of health services with the needs of health system users. [94] With the exception of Pernambuco, states with the highest technical efficiency scores in the basic DEA models also showed values greater than or equal to 1 in the Malmquist Index (in the catch-up and frontier-shift effects).

3.5. Concluding remarks

This study provides insights into the relative efficiency of the public services of kidney donation and transplantation, based on benchmarking Brazilian states in recent years. In general terms, the low average of efficiency scores in the analyzed years (<0.70) indicates significant room for improvement in the allocation of resources.

This result is consistent with previous applications of DEA in the ODT literature. Costa, Neto, and Sampaio (2014) [25] analyzed the conversion of expenditures on hospital and professional services into the number of kidney transplants performed in Brazil's states from 2006 to 2011. The data showed a significant discrepancy in the number of transplants performed, with most states failing to increase productivity in the years analyzed. However, the technical efficiency scores were generally higher and presented a lower coefficient of variation than those obtained in the present study. Marinho and Cardoso (2007) [26] compared transplant expenses with quantities of various organs transplanted in Brazil from 1995 to 2003. That study also showed an overall deterioration of performance, with a slight performance improvement in the last three years of the analyzed period. Again, the mean efficiency scores at each year in both the CRS and VRS models were higher than the mean efficiency scores obtained in the present study.

The scale inefficiencies observed by Costa, Neto, and Sampaio (2014) [25] and Marinho and Cardoso (2007) [26] signal an inadequate size of operation. In this study, the predominance of IRS suggests a subdimension of the operating structure of the states. However, dimensioning decisions regarding the consolidation or specialization of ODT health services should take into account their geographical distribution in the vast national territory, and population access.

The comparison of the results of the present study with the prior literature indicates a high and persistent level of inefficiency in the Brazilian public transplant system and a lack of improved efficiency in recent years. More specifically, the decrease in technical efficiency scores in the study period, especially in the North and Northeast states, may be due to hindered diffusion of successful management practices and technologies that could positively impact healthcare delivery. Examples of such technological advances in the field of ODT include new exams for more agile diagnosis of brain death and new communication tools to improve interactions between the families of deceased donors and health professionals. However, improvements in this matter depend not only on the availability of technologies but also on their adoption by health managers at the state level.

As indicated in the most recent report by the Brazilian Union Court of Auditors, [95] inefficiency may be due, at least in part, to managerial shortcomings. Such challenges include computerized systems with security failures, data that are not standardized or are out-of-date, and difficulties in the communication and transportation of organs between states. The public services of organ procurement, donation and transplantation appear to be hindered by bureaucratic requirements and long waiting times at every stage. Moreover, there is evidence of unequal access between Brazilian citizens with health plans and those who depend on the public health system. [95] In addition to the lack of medical resources in public hospitals, there is a lack of continuity of long-term public awareness campaigns and training for health professionals, often driven by short-term political interests. [9,95]

Furthermore, the striking differences in efficiency scores between Brazil's regions suggest asymmetries in resource management. This finding highlights the importance of benchmarking for allowing states with the worst performance to learn from best practice and successful innovations in other locations. Additionally, given the socioeconomic inequalities amongst Brazil's states and regions, it is important to examine the impact of the contextual variables specific to each state. Although beyond the control of ODT state management, factors such as the number of hospitals and health professionals, population density and the percentage of illiterate persons could help

explain the efficiency results. The impact of these factors could be assessed in future research by using regression analysis applied to DEA.

Another possible complementary mode of research would be a qualitative investigation, such as case studies of states with the worst and best performances, with the aim of better understanding successful practices and the management obstacles faced by health managers. Moreover, a longitudinal assessment contemplating a longer period of time could facilitate the monitoring of the results of the adoption of specific initiatives (such as educational campaigns for the general population and programs for hospital quality and professional training).

Although this study provides enlightening insights into the relative efficiency of Brazilian ODT public services, the findings should be interpreted with some caution. Although it is robust and widely used, DEA has some inherent shortcomings. Firstly, it measures relative efficiency. Thus, states with scores equal to 1 are only efficient when compared to the sample units, and not in absolute terms or relative to external or international standards. In addition, the accuracy of DEA results depends greatly on the variables used. Omitted variables can lead to measurement errors, due to failure to properly cover all relevant aspects of the DMU production process. To minimize this limitation, we selected variables previously used in the literature and recommended by Brazilian health specialists working in the ODT field.

The PCA method used for variable reduction also adds restrictions, as changing the mix of inputs and outputs of inefficient DMUs may produce significantly different results. However, there is a trade-off between the use of a complete dataset and improved discrimination power in DEA models. [96] In this study, we opted for a better ability to distinguish between efficient and non-efficient units.

Another issue impacting the robustness of the results is the database dimension. Filtering of the data led to the exclusion of states due to missing data, and this change from the original sample may influence the efficiency frontier analyzed. However, this limitation is inherent in the use of secondary data. Finally, the efficiency scores in this study are not presented in confidence intervals, not being possible to apply error and dispersion measures. [97] In short, the drawbacks of deterministic methods such as DEA include a lack of statistical rigor in the results [98] and high sensitivity to extreme values or outliers. [99]

However, given the importance of the management aspects of ODT services, the benefits obtained by the systematic application and cautious interpretation of the DEA results would seem

to overcome these methodological limitations. In addition to its practical focus and motivation, this study can serve as an academic stimulus, given the scarcity of efficiency and benchmarking studies in the ODT literature. For health managers, it is essential to know the productive process of interest and its performance over time. This enables the identification of areas to be improved and helps in subsequent decision-making. For policy makers, the benchmarking of states draws attention to the need for better articulation over Brazil's vast national territory and its particularities, allowing the identification, adaptation and dissemination of good management practices.

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4. THIRD ARTICLE – Exploring State Transplant Coordinators' views on factors influencing the performance of organ donation and transplantation services: A qualitative study in Brazil

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Abstract

Brazil has the largest public program of organ transplantation in the world, only behind United States in absolute number of surgeries. Yet, the National Transplantation System faces increasing waiting lists and numerous managerial challenges. Despite their prominent role of managing donation-transplantation services in their respective federal units, qualitative studies aimed at state transplant coordinators professional views are lacking. From the perspective of such actors, this study aims to explore the influencing factors of performance at Brazilian donation-transplantation services. Semi-structured interviews were conducted with 15 out of the 27 Brazilian state transplant coordinators. The interviews were recorded, transcribed and underwent content analysis for key themes identification. Among the factors identified is the use of indicators as a basic management tool. They help identifying inefficiencies, guide decision-making on the need for new initiatives or investments and ground the dialogue with actors such as hospitals managers, donation teams and government representatives. Other factors identified for its positive impact are the relationship built with hospitals and other transplant centers; the state political stability; the altruistic interpersonal profile and relational skills of coordinators; and the provision of media coverage and campaigns to raise public awareness on organ donation. Several factors were acknowledged by the state transplant coordinators as enablers or obstacles of performance, belonging to the political and regulatory surroundings, to the internal management of state transplant centers and donation teams, and to the relationship with patients and population. The article intends to contribute to the healthcare practice and literature by developing a conceptual

framework that provides policy-makers, managers, practitioners and researchers an overview of the multiple factors affecting the performance of donation-transplantation services. Based on the identified factors, a list of good practices is proposed and provide a basis for future research.

Keywords
Qualitative research; Transplant coordinators; Organ Donation and Transplantation.

4.1. Introduction

For thousands of patients with a vital organ impairment, transplantation may be the best or only option in terms of survival and quality of life, replacing financially and socially costly therapies like dialysis. For health systems, it often represents lower costs per patient compared to dialysis (Jarl et al., 2018; Camargo et al., 2018; Silva et al., 2016).

In the global scenario, as well as the United States and Spain, the Brazilian National Transplantation System (SNT) stands out for its numbers. The SNT was established in 1997, and currently represents the largest public program of organ transplantation in the world, only behind the United States in absolute number of surgeries. Every Brazilian patient with a chronic disease that depends on a transplant has the right to receive an organ through the Brazilian Unified Health System (SUS). As a result, more than 90% of the transplants are financed with public funds, including all transplant-related appointments, procedures and surgery (http://portalms.saude.gov.br/).

The number of solid organ transplants has increased significantly in the last decade, from 5,374 in 2008 to 8,725 in 2018, accompanied by an increase in public resources spent in this field (RBT, 2018). In 2018, SUS spent over one hundred and eighty million Reais with organ donation and transplantation (ODT), including surgeries, exams, medications, staff and hospital services. This value is 238% higher than the expenditure carried out in 2008.

Despite improvements, in 2018 there were 33,454 patients on the transplant waiting list in Brazil. In the same year, Brazil presented 10,779 potential donors, but only 3,531 of them turned into effective donors (RBT, 2018). These numbers signalize challenges to the effectiveness of the donation process and thus increase donation rates.

In addition, as stated by the latest report of Union Court of Audits regarding the Brazilian ODT activities, the SNT faces several managerial problems, including (Vilaça, 2006): Lack of

cost-effectiveness analysis regarding adopted medical procedures; Incomplete and technologically outdated information systems, hampering data integration at national, state and hospital levels; Low dissemination of medical protocols and managerial practices; Loss of potential donors due to poor infrastructure and lack of planning at public hospitals, such as shortage of ICU beds, broken equipment for brain death diagnosis, delays in laboratory tests and in transplant teams allocation.

Inefficiency in this field was also reported by studies quantitatively estimating the technical efficiency of Brazilian states, concerning to wastes in the conversion of inputs (as financial, human, infrastructure and/or material resources) into outputs (namely, the number of transplants performed by each unit of analysis). The studies found a significant level of inefficiency, meaning that, compared to other units in the sample, and, given the resource level applied, most of Brazilian states could have generated a great number of transplants (Siqueira and Araujo, 2018; Costa et al., 2014; Marinho and Cardoso, 2007). The results suggest that performance problems are not exclusively associated with the availability of resources in the SUS, but also with the managerial aspect of resource allocation.

Previous studies have focused on hospital transplant coordinators worldwide, more specifically on this position scope of work (Teixeira et al. 2014; Macnatt 2008). Other studies focused on specific managerial initiatives aimed to improve ODT results in Brazil, such as the hospital implementation of a Quality Management Program (Araújo, Tavares, de Vargas and Rocha, 2015) or of full-time organ donation teams (Andrade and Figueiredo, 2019; Sarlo et al., 2016). In addition, a systematic review aimed to map what efficiency indicators are used in the literature to map the performance of ODT services (Siqueira et al., 2016). The efforts also included initiatives of biovigilance applied to transplants worldwide, aiming to monitor and control the risks and adverse events on the clinical evolution of recipients and living donors (Roza et al., 2019). However, a similar study converging the perceptions of state transplant coordinators on the multiple factors positively or negatively affecting ODT performance was not identified so far.

Thus, despite the abovementioned challenges of ODT services, which are human-intensive and technically complex, there is no extensive literature aimed to understand managerial problems and practices within this field (Tong, Morton & Webster, 2016). In this scenario, a detailed analysis of factors influencing the performance of ODT services is expected to improve its management.

The general objective of this study is to explore, in the perspective of state transplant coordinators, how the ODT performance in Brazil can be improved. To do so, two specific

objectives unfold: a) To identify what factors are perceived as enablers or obstacles for ODT performance; b) Based on identified factors, to propose a list of managerial recommendations.

The performance as discussed in this study refers to a wide-ranging construct covering the basic components of a healthcare service delivery: structure, processes and outcomes. The first one is the structural setting where the care takes place, encompassing internal policies, physical infrastructure, material, financial and human resources. The second one represents the processes of care, regarding treatment, prophylaxis, diagnostics or patient monitoring. The third domain refers to the outcomes of care, that, in the case of ODT services, can be exemplified as an organ transplantation, a graft rejection episode or the time of survival of a transplanted patient (WHO, 2006; Institute of Medicine, 2001; Donabedian 1990). Hence, the investigation comprises any aspects positively or negatively impacting the structure, processes or outcomes of ODT services.

The study takes the perspective of Brazilian state transplant coordinators, responsible for managing ODT services in their respective federal units. With no similar study identified so far, this study intends to provide health managers and policy-makers an initial framework of factors for discussion ODT performance, also drawing closer the fields of medicine and management.

4.2. Influencing factors of health services performance

There is abundant and well-stablished evidence that the outcomes of healthcare services are impacted by social, economic, behavioral and environmental factors. Thus, it is desirable that health services assessment acknowledge the complexity and heterogeneity brought by such factors (Schold, Phelan & Buccini, 2017). Yet, when it comes to ODT, the performance of transplant systems, organ procurement organizations and transplant centers is often assessed solely by clinical indicators as the number of transplants, graft failures or post-transplant survivals (Schold, Phelan & Buccini, 2017; Wijesinha et al. 2019; Alexandrine et al. 2019). Although utterly relevant, such measures do not account for the multiplicity of factors affecting ODT activities.

This issue was also discussed in a recent systematic review of measures used to monitor the performance of ODT processes. The most frequent measures identified are non-risk-adjusted outcomes, such as the number of brain death notifications and the conversion rate of potential donors into actual donors. In turn, few measures focus on tracking and benchmarking preestablished goals, the quality of services provided, the logistical and managerial challenges of

properly allocating available resources, and the subjective aspects affecting donation such as the attitude of healthcare users and professionals (Siqueira et al., 2016).

Although many studies addressed aspects other than clinical outcomes, as the factors influencing families' decision to donation, the service quality-assessment by patients and health providers, health professionals training, knowledge and attitude towards ODT (Andrade and Figueiredo, 2019; Jawoniyi et al. 2018; Chakrabarti et al. 2016; Araujo and Siqueira 2016; Tong et al. 2013), we did not identify so far previous studies offering a broader view on the multiple factors influencing ODT, thus accounting for internal and external domains of health delivery.

In the absence of conceptual models aimed at ODT activities, this study borrows contributions from the health management literature. We targeted studies discussing the manifold factors that affect health organizations and services. Rather than considering existing models as independent and competing, we intended to recognize their complementarities, encompassing dimensions otherwise neglected in isolated models. It is noticed that there is not a consensus of factors. The studies present different degrees of amplitude, including a greater or lesser range of factors. Table 1 summarizes, in a non-exhaustive list, the factors identified in the studies of Williams, Brown & Healy (2018); Valaitis et al. (2018); Oner et al. (2016); Taylor et al. (2015); Mosadeghrad (2014a); Mosadeghrad (2014b); Afsharkazemi et al. (2013); Liu & Itoh (2013); and Vincent, Taylor-Adams & Stanhope (1998). The aspects emerged from this literature fit into four main domains concerning the performance of health services/providers: a) Internal management; b) Organizational characteristics; c) Environment; and d) Interface with patients and general population.

Table 1. Themes emerged from literature

INTERNAL MANAGEMENT
• Financial management: budgetary constraints, payment and financing system, technology investments.
• Resource management: physical infrastructure, availability of material and human resources; investments in technology.
• Relationships management: relationships with stakeholders, collaborative approaches, communication mechanisms and strategic coordination between partners.
• Performance assessment: investments in information systems, self-assessment processes, goals and indicators monitoring.

• Quality management: availability of information to the public on the cost-effectiveness of treatments, patient safety, evidence-based practices, use of clinical protocols, etc. • Staff management: Staff turnover, training, payment, motivation, physical and mental health; Optimization of employees' scope of practice; Skills, knowledge, personal/professional needs and motivation; Ethical and social considerations on the impact of the health services; Number and mix of employees, workload, work shift, administrative and managerial support. • Communication and team management: mechanisms of verbal and written communication, processes of supervision and feedback; team management, work in interdisciplinary teams.
ORGANIZATIONAL CHARACTERISTICS
• Health service characteristics: medical specialty, service volume, service-mix, case-mix. • Organization characteristics: size, location, ownership, organizational structure. • Institutional Strengths and Constraints: internal policies, power relations and top management support. • Strategic decisions: Organizational goals and vision, including acquisitions and mergers.
ENVIRONMENT
• Political-regulatory context: political interest, cooperation with interest groups, services regulation. • Socioeconomic context: Economic incentives and climate; External competition, market demand, supplier power. • Demographic context: Characteristics of the country, region or health system where the service is.
INTERFACE WITH PATIENTS AND GENERAL POPULATION
• Patient-provider relationship: Patients personality and subjective considerations on the service; Patients' needs, personal and social dimensions; Health-condition severity.

Source: Developed by authors

4.3. Methods

4.3.1. Study purpose and data collection

The general aim of this study is to gain in-depth insights on how to improve the performance of ODT services, particularly in the Brazilian context. For that purpose, its two specific objectives comprise: a) the identification of factors that, in the perception of state transplant coordinators, are enablers or obstacles of the performance; and b) based on the identified factors, propose a list of managerial recommendations. Due to its adequacy to the research objective, a qualitative approach was employed. Qualitative methods allow in-depth information on complex and scarcely explored subjects, being suitable to address "how" and "why" questions even when academic topic is in

early stages of development and there are few previous studies on the phenomenon (Meyer, 2015; Mack et al., 2005).

The data was collected through semi-structured interviews. The method allows interviewees the flexibility and openness to speak freely, providing rich and detailed responses in their own words, whilst allowing the interviewer to deepen into issues of interest that may arise during interviews (Meyer, 2015; Mack et al., 2005). To triangulate evidence and better understand the functioning of ODT services, we also looked at the SNT and state transplant centers website, laws, technical regulations, official documents and news related to ODT activities in Brazil.

4.3.2. Settings, participants and data analysis

In the first stage of field research, two interviews were conducted with ODT practitioners occupying managerial positions. This pre-test stage aimed to gain insights on the ODT sector and check the adequacy of the interview script, which was previously drawn up considering the literature review. This stage led to minor changes in the interview protocol. In the next stage, a standardized e-mail was sent to all 27 Brazilian state transplant coordinators. The message informed the research general objective, the researchers names and academic background and an invitation for voluntary participation in the research.

Semi-structured interviews were conducted with 15 state transplant coordinators who agreed to participate. The interviews lasted between 60-80 minutes. Before starting the interviews, the research aim and the interview estimated length were explained. The interviewer also mentioned that the interview audio would be recorded to facilitate further data analysis and that the participants names would not be identified throughout the text. None of the participants opposed to the interview recording. During interviews, to seek more details and/or to confirm the correct understanding, follow-up questions were made in reference to the answers given.

The coordinators interviewed work at the four Brazilian regions, representing states with distinct socioeconomic realities and experience on ODT services. Given the geographical scope of research, covering the continental national territory, the interviews were conducted via Skype and recorded through Skype Recorder software. Table 1 presents the profile of interviewees.

The coordinators were chosen as a focal point given to the breadth and relevance of their work as managers of Brazilian transplant services at state level. The unique characteristics of their

position demonstrate potential contribution to the body of knowledge under examination and suitability to the research objectives (Miles, 1994; Anderson, 2010).

As previously mentioned, each Brazilian federal unit has a transplant coordinator and its respective state transplant center. This coordination model in force was inspired by the Spanish transplantation system. The coordinators' scope of work includes the synchronization of all elements that encompass ODT activities at the state level, serving as a support and communication channel and a reference point to maintain quality and ethical standards in transplant services (Elizalde & Lorente, 2006). As discussed by McNatt (2008) the work of a Transplant Coordinator has the primary goal to increase the numbers of and improve the outcomes related to ODT activities, through the facilitation and coordination of all relevant processes and actors (Teixeira et al., 2014; Mcnatt, 2008; Blumenthal, 2007; Falvey, 1996).

Table 1. Profile of the interviewees

ID	Professional background	Time in the position	Full-time employee
I1	Nurse	8 years	Yes
I2	Physician – hepatologist	3 years	No
I3	Physician – hematologist	3 years	Yes
I4	Social worker	15 years	Yes
I5	Nurse	18 years	No
I6	Clinical Psychologist	4 years	Yes
I7	Nurse	8 years	Yes
I8	Nurse	7 years	Yes
I9	Pharmacist	2 years	Yes
I10	Physician – nephrologist	3 years	Yes
I11	Physician – intensivist	15 years	No
I12	Physician – nephrologist	1 year	Yes
I13	Nurse	6 years	Yes
I14	Physician – intensivist	7 years	No
I15	Physician – sanitary	13 years	Yes

The interviews transcriptions were examined individually by the researchers, seeking a consensus in the analysis. Content analysis was used to identify key themes and detect factors affecting ODT services. The thematic coding was performed using Microsoft Excel software and enabled to consolidate factors into logical and meaningful groups, as well as to draw connections among groups. The information collected were examined in light of the evidence from the literature, favoring the apprehension of convergencies or divergencies (Miles & Huberman, 1994).

As an exploratory qualitative study, we not indented to quantify, accept or reject theoretical propositions previously hypothesized.

Finally, regarding the research ethics, all protocols for this study were submitted to and approved by the Research Ethics Committee at the Federal University of Rio de Janeiro. All participants provided written informed consent.

4.4. Results

4.4.1. Internal management

Regarding the '*communication and team management'* domain, it was clear during interviews that the state transplant coordinator position requires, besides technical knowledge on ODT activities and its operation, a strong relational component. Social skills are aimed to articulate in the political and hospital environments, in the media, with patients and families from different socioeconomic situations, and with the general population. Internally, coordinators also need to manage their teams and organize service scales, so that the state transplant centers run 24 hours, under on-call shifts.

Given the participation of several institutions in the ODT processes, relational and people management skills help recognizing and motivating all relevant partners, so that they act in favor of ODT results. In this sense, coordinators affirmed to spend a significant amount of their work hours in relational activities such as meetings for the communication, awareness and training of hospitals' health professionals and donation teams. Likewise, they depicted interactions to raise awareness and solve doubts of private companies, schools, neighborhood associations, chronic disease associations, medical and nursing universities, medical councils, among others. It is also common to give interviews on radio or television, and to participate in events with media coverage. Such activity is seen as a way of disseminating the results and social relevance of ODT activities, thus raising familiarity of general population with the subject.

Concerning the '*staff management'* domain, as cited by most interviewees, professional challenges also derive from the absence of a standardize training aimed at state transplant coordination, especially regarding the managerial tasks. After becoming coordinators, some of the interviewees had the self-initiative to seek managerial training. But at large, they have to learn "in practice" how to deal with management challenges within their work. This self-drive to keep professionally qualified and up to date, as well as compatible personal values as empathy and

altruism, are reiterated in the interviews. This suitable profile creates greater professional engagement with ODT activities and is also valid for professionals like hospital transplant coordinators, donation teams, nurses and doctors.

Another aspect identified is the lack of specific training, recognition and compensation for professionals involved in ODT activities within the Brazilian SUS. Different from other hospital procedures, doctors in public hospitals do not receive specific compensation for transplant surgery. The same happens for neurologists responsible for the complementary tests of brain death diagnosis. Unlike the Spanish model, there is also no remuneration for the position of hospital coordinator – those professionals working within hospitals to assist and conduct processes that allow the donation, procurement and transplantation of organs.

Despite such issues, the interviewees displayed a high level of interpersonal involvement and intrinsic motivation to work with ODT, for being able to positively impact mourning families and patients waiting for a transplant. This seems to overcome practical obstacles, including the abdication of professional possibilities such as medical practice and performing medical procedures or exams.

Other factor reiterated for its negative impact is the staff turnover, compromising efforts in training and relationship building. It was exemplified by one interviewee that a change in a hospital direction can result in the replacement of several healthcare professionals, undermining months of awareness and training efforts on ODT activities. It can also hamper the access to medical records and data that hospitals are not legally required to send to the state transplant centers. Human-related factors exemplified in the interviews also include unmotivated healthcare professionals, a breach of contract with a hospital neurologist, hampering protocols of brain death, or because the person in charge of the hospital's donation team went on vacation, leading to increased underreported encephalic death cases. This requires close monitoring and continuous communication of hospitals performing ODT by the respective state transplant center.

In the '*financial management'* domain, because state transplant centers are part of their respective State Health Secretariat, they have no financial or executive autonomy. Besides, there is an absence of cost-effectiveness analyzes of expenses per patients, hospitals and along each stage of the ODT process. Resulting problems also underly the *resource management* domain, with bureaucratic and slow processes for bidding or purchasing products and contracting services.

Referring to '*relationships' management domain'*, cordial interactions with other state transplant coordinators were highlighted by interviewees as a positive aspect. Some coordinators cited on-site visits to federal units with prominent ODT results, aimed at benchmarking good practices and learning with the problems already overcame by other states. The interactions cover the operation of state transplant centers and how coordinators operationalize technical and relational issues, such as the interaction with the health secretariats, the relationship strategies with donation teams and the initiatives to increase donations at each state. In addition to face-to-face contacts, online communication, especially via WhatsApp, was observed. The coordinators have a WhatsApp group where they openly ask questions, express opinions, exchange experiences and keep abreast of legislation. The channel allows coordinators to seek guidance on exceptional cases that have already been witnessed in other states, to debate the understanding of colleagues on new ordinances and to share articles that support different points of view regarding ODT advancements. It is worth mentioning that most interactions alluded occurred by coordinators' self-initiative.

In '*performance assessment* domain', all interviewees cited as essential the use of ODT result indicators. This data represents a managerial tool that guides decision making in several aspects, including the need for new investments, as well as training and education initiatives. The longitudinal performance analysis allows monitoring goals in the long term and favors the identification of structural changes, such as new public policies, that may have contributed to processes improvement. Indicators are also used for evidence-based argumentation and motivation with government representative, hospital managers, ODT teams, among other stakeholders. They underlie suggestions such as an employee's dismissal or training, in a way that errors can be rationally faced and addressed. Thus, indicators can provide positive feedback to successful efforts, pinpoint the necessity for changes when the performance falls short to established goals, or ascertain the effectiveness of specific actions such as courses and campaigns.

It is observed that indicators are effective when, in addition to pointing out inefficiencies, are followed by corrective actions. In particular, educational initiatives are seen as an efficient strategy, being usually followed improvements in the targeted area. Explicitly, the training of hospital donation teams for performing family interviews is acknowledged by many interviewees for effectively tackling high rates of family refusals to organ donation.

Most coordinators believe that in recent years managerial reports have improved in terms of data coverage and reliability. This is especially relevant once state transplant centers monitor ODT

results by using both data generated internally and collected externally at hospitals, medical laboratories, etc. However, it was clear in the interviews the existence of a contrast among states, regarding the development of databases and sophistication in the analysis of information. In most state transplant centers, data input, tabulation and consolidation are made manually in an Excel worksheet, thus characterizing a greater susceptibility to human failures.

Due to the involvement of several people in the process of data collection, all coordinators stated performing manual data check procedures, with more than one person checking the data received or a same person comparing the data in different sources. One example is the data check between the number of deaths provided by hospitals and of death certificates from the Brazilian health department. In the perception of coordinators, data control is facilitated when there is a greater proximity to the professionals responsible for collecting the information within hospitals.

Although interviewees recognize the relevance of ensuring reliable and standardized ODT information, few coordinators reported using more sophisticated software or data analysis tools, as well as the existence of an employee who is trained and exclusively dedicated to data management activities. This happens because, in general, State Transplant Centers work with limited number of employees and deal with several problems that require immediate resolution. Thus, the lack of human resources is a limiting factor for the development of a more elaborate ODT database, and efforts for improving the indicators' system are often postponed.

The indicators are also used for establishing and tracking goals, at different levels of aggregation. At national and state levels, there are goals agreed with the Ministry of Health and the State Department of Health. They are also elaborated internally, at the State Transplant Centers, or together with the donation and/or transplantation teams. The results are compared with previous periods or with the national and regional mean, also observing epidemiological levels suggested by medical literature and international benchmarks as the Spanish donation system. The goals are monitored in different reference periods. If a state presents a small ODT volume, it may need to work with more aggregated data as pluriannual or annual results, while high-volume centers can also analyze weekly or monthly data.

Most interviewees mentioned to only monitor those indicators mandatorily sent by hospitals. Although allowing richer performance appraisals, to continuously gather and analyze data for new indicators relies on employee’s availability at the State Transplant Centers. As a result, complementary indicators are scarce and generally used in a sporadic, non-consistent manner.

In turn, coordinators portrayed a continuous effort to raise hospitals' awareness towards data collection and documentation on ODT activities. However, examples of hospitals sending delayed and inconsistent information to their respective state transplant center are plentiful. As alluded during interviews, data compliance problems tend to increase at hospitals operating with incomplete and non-electronic medical records, when the hospital top-management doesn't seem to support the ODT cause, and when there are no financial/non-financial incentives tied to the performance of professionals working with ODT activities.

Within the '*quality management* domain', coordinators cited additional variables that should ideally be included in the list of mandatory indicators foreseen in the Brazilian legislation, sent from hospitals to their respective State Transplant Center and to the SNT's system. These variables refer to the quality of ODT services and the reasons why families refuse to donate organs for transplantation. Other cited data gap refers to the healthcare humanization received by patients and their families, due to its impact on families' decision to organ donation. The criteria for selecting transplant recipients could also benefit from qualitative data, covering not only medical aspects but also the support network that a transplanted patient requires.

In the donation stage, a discussed data gap refers to more-detailed information on the causes of death within hospitals. This information would allow better estimating the potential donor pool of each hospital or geographic area. It could also help pointing out inefficiencies on the identification and clinical maintenance of potential donors. Further desirable information exemplified in the interviews comprise the transplantation follow-up, as patients' survival and quality of life, re-transplantation, graft rejection episodes, adherence to immunosuppressive treatment and patient return to social and work activities. As explained by one interviewee, this type of information is an important proxy for the quality of transplantation services and should ideally be considered for re-accreditation of transplant teams.

4.4.2. Organizational characteristics

Within '*institutional strengths and constrains* domain', it was observed that an overly conservative approach towards non-absolute contraindications to donation, at hospitals performing ODT in a given state, can result in low rates of organ utilization. Some of the interviewees also cited the importance of having active donation teams systematically operating within hospitals structure, helping hospitals to provide a greater support for ODT activities. Other desirable practice

is the commitment term with the respective state transplant center, for monitoring hospitals organ-donation results against established goals.

State transplant centers present distinct approaches for dealing with hospitals and its donation teams, and the extent and frequency of those contacts depends on the representativeness and performance of the hospital's ODT results. The interactions increase when a sharp drop in ODT numbers is observed in a given hospital. In general, hospital management by the State Transplant Center is carried out through phone calls, on-site visits, courses, lectures, meetings with hospital's directors, managers and healthcare professionals directly or indirectly working with ODT.

Such meetings are meant to set goals and raise awareness regarding the social and ethical relevance of organ donation, the importance of collecting data for ODT measurement, and the need of motivating, training or even substituting healthcare professionals when they do not seem to present a compatible profile for working in this field. One occasion where the state transplant center presented to a hospital a new protocol to guide ICU professionals in the identification, diagnosis and maintenance of brain-dead patients was cited to exemplify a topic discussed in such meetings. However, there is no formal hierarchy requiring that hospitals follow the practices suggested by the state transplant center.

In the '*strategic decisions'* domain, some coordinators also stated the relevance of public-private partnerships, since many hospitals operate with an insufficient amount of human, physical and material resources. The resource scarcity translates into overloaded doctors, unmotivated and poorly trained healthcare professionals, crowded ICUs, failures in the welcoming of patients and humanization of care, and several delays in the healthcare process. In turn, this negatively affects the identification and clinical maintenance of potential donors, as well as the family decision towards donation. In this sense, partnerships would improve the availability of ICU beds, healthcare professionals, equipment, procedures and tests required for ODT services. However, this requires an attractive remuneration of private hospitals for ODT procedures performed.

4.4.3. Environment

Regarding 'political and *regulatory context*' domain, the interviewees reported that it is essential for a coordinator to possess technical knowledge on the rules and legislation of SUS and SNT, as well as its political peculiarities at state and municipal levels. Keeping up to date with

new laws, ordinances and technical regulations ensures acquaintance on fundraising possibilities, financing mechanisms and legal operating requirements regarding ODT services.

It was mentioned by several coordinators that legal and bureaucratic questions are inherent to their daily work. The involvement with supporting documentation, memos, bidding processes, among others, means less time devoted to strategic issues. In the It is also noted that political skills are highly desirable to build a good relationship between the State Transplant Center and the State Department of Health, facilitating partnership projects and fundraising agreements.

Regarding the '*socioeconomic context'* domain, coordinators noted that the socioeconomic heterogeneity among Brazilian states mirror onto ODT results, especially when public health investments do not target inequalities. In this perspective, one interviewee noted that prominent transplant centers tend to be located at richer states, with greater levels of federal and state government funding to healthcare and transplantation services. However, this view is not unanimous. Another interviewee remarked that the management of ODT services is the most important aspects for the results obtained, regardless of the state socioeconomic development.

4.4.4. Interface with patients and general population

Regarding the 'patient-provider' domain, the investment in educational and media campaigns covering ODT activities was cited as a positive factor, given its potential to demystify organ donation and portray it as an action of empathy. In turn, the lack of knowledge regarding brain death and the dissatisfaction with the healthcare provided were brought to light for its negative impact on family's decision to organ donation.

4.5. Discussion

Addressing the first specific objective of this study, table 3 depicts the main factors identified for its impact on ODT services performance. The first column presents aspects identified from the interviews and distributed according to the topics identified from the literature. The second column presents interviewers' quotes within each topic. As also portrayed in figure 1, several factors were identified, pertaining to four main topics: a) the internal management of ODT services; b) the organizational characteristics of state transplant centers and hospitals, b) the environment context of ODT services and c) its intersection with patients, families and general population.

When comparing the categories and subcategories of factors impacting the health services/providers performance, it is possible to draw a clear parallel between issues emerged from literature and from the interviews. More specifically, all aspects brought in the coordinators' discourse fit into one or more subcategories present in the literature examined. In turn, not all aspects from literature were quoted by the interviewees.

Within the "*Environment*" topic, the demographic context of ODT services and how it can affect ODT results were not stated. It is worth mentioning that every Brazilian patient with a chronic disease that depends on an organ transplant has the right to receive an organ at expenses of SUS. Thus, ODT services are performed irrespective of patients age, gender, income or educational level. Within the "*Internal management*" topic, the issues of staff management related to employees' physical and mental health were not mentioned. However, the remaining aspects, including workload, skills and knowledge, personal and professional needs and motivation, were expressed during interviews. Within "Organizational characteristics" topic, aspects related to acquisitions and mergers and to the ownership of health services/providers were not alluded. Once again, is worth stating the specificity of Brazilian ODT services as a public health program. The state transplant centers are part of their respective State Health Secretariat and are mostly composed by public servants.

The results concerning the working scope of coordinators meets the evidence suggested by Teixeira et al. (2014) and Macnatt (2008), indicating a wide variety of professional categories occupying the position and the lack of requirements on the educational and professional training of Transplant Coordinators. Despite the relevance and complexity of their work, coordinators struggle due to a lack of specific training for this position, especially regarding managerial tasks.

As argued by Teixeira et al. (2014), this could be partially addressed by the professional certification of this category. The certification verifies the qualification to perform a job, in terms of required technical knowledge and interpersonal skills, being associated with greater professional status and better transplant results. However, efforts to certificate Transplant Coordinators profession are sparse, with isolated initiatives in Europe, United Stated and United Kingdom. (Teixeira et al., 2014). Additionally, there is little scientific evidence on the optimal staff-number and skill-mix required for ODT services with different sizes and intensity of operations. This lack of standardization hampers the definition of good practices and a well-delimited scope of work for transplant coordinators (Mcnatt, 2008).

Their multidisciplinary work requires dealing with many stakeholders, including hospital directors, doctors, nurses, IT specialists, psychologists, social workers, among others. By coordinating a complex, highly regulated and publicly visible health service, coordinators also deal with the media and government representatives (Teixeira et al., 2014; Hauff, 2007).

At large, coordinators need to work together with the hospitals and teams performing ODT on their states. Measuring and monitoring of ODT results at hospital, municipal and state levels, seeking continuous improvements in the area, constitute a relevant task (Teixeira et al. 2014). In order to act in accordance with the current rules, the position requires continuous updating of technical and legal knowledge (Mcnatt, 2008). In addition, budget constraints faced by health systems intensify the pressure for managerial efficiency in this position (WHO, 2010).

Consistent with the results of this study, empirical articles conducted in Brazil also emphasized the relevance of organizational/managerial factors for ODT results. A Rio de Janeiro hospital noted process improvements on ODT activities after the implementation of a Quality Management Program, leading to greater learning capability for errors detection and behavior correction (Araújo, Tavares, de Vargas and Rocha, 2015). Rio de Janeiro also experienced a sharp increase in the referrals of potential donors, donor conversion rates and donation rates in the years following the implementation of full-time organ donation teams in the structure of selected hospitals (Sarlo et al., 2016). Santa Catarina achieved similar improvements after articulated ODT initiatives in the state's hospitals. The efforts included: a) Implementation of a remuneration system for hospital transplant coordinators; b) Development of hospital training programs focused on ODT processes, especially regarding family interview to organ donation, potential donors identification, brain death diagnosis and maintenance of deceased donors; c) Implementation of full-time organ donation teams in the hospital structure; d) Involvement of intensive care doctors in transplant coordination (Andrade and Figueiredo, 2019). However, is worth mentioning that several other aspects discussed during interviews, within and without the organizational domain, remains scarcely investigated in ODT literature.

In particular, the identified factors focus largely on human resources, relational dimensions and performance measurement. The first one refers to the interactions among relevant actors, such as other state transplant centers, government representatives and hospitals performing ODT. The second one refers to the staff management on state transplant centers and hospitals, involving practices that aim awareness and support towards ODT activities. Both aspects above-mentioned

are supported by indicators, that guide investments such as new government-funded public campaigns, and corrective actions such as new efforts for ODT training at hospitals or the dismissal of professionals who do not have a compatible profile to work in this field.

The growing relevance of performance indicators is observed in Brazil as well as in other countries. Data such as the number of notifications of Brain Death and the number of donated and transplanted organs are used by international institutions such as the Global Observatory of Organ Donation and Transplantation (GODT) and by several successful transplant services, including the United States, Spain and Turkey. The performance indicators allow monitoring and benchmarking results over time and considering different levels of aggregation, such as by hospitals, municipalities, regions or even countries. In a systematic literature review describing the performance measurement in the ODT field, the significant number of indicators identified signals its relevance as managerial tool. However, the study also identified a low standardization of indicators adopted and measurement gaps in several stages of the ODT processes (Siqueira, Araujo, Roza & Schirmer, 2016). Such gaps were also identified in the interviews, relative to objective and subjective aspects of the patient's follow-up in the post-transplant, the motivations of family refusal for organ donation and the quality of services delivered.

Addressing the second specific objective of this research and drawing from the main problems and facilitators identified through the interviews, figure 2 represents a set of recommendations aimed to enhance Brazilian ODT processes.

4.6.Concluding remarks

This study analyzed multifaceted factors influencing the performance of ODT services in Brazil, considering the perspective of those who manage the services at the state-level. For this purpose, a qualitative study was carried out with 15 state transplant coordinators. The results indicate acceptance of the literature evidence that health services performance is affected by internal and external factors encompassing different stakeholders. More specifically, it was noted that the performance of ODT services relate to the: a) administration of state transplant centers; b) political and regulatory environment surrounding these services; c) interpersonal relationships and job functions of state transplant coordinators; d) patients, their families and the general population.

Table 3. Influencing factors of performance on state services of ODT

Topic: Internal management	Transplant Coordinators' quotes
Financial Management • Lack of detailed analyses of expenditures and resource needs. • No variable-remuneration linked to the attainment of ODT goals. • No specific remuneration for ODT procedures as transplant surgery and confirmatory tests for brain death diagnosis at public hospitals.	*I10: "We don't have access to money. If a computer breaks, I have to file a formal purchase order. It is a real journey to replace it."*
Resource management • Slow and inflexible process for purchasing, bidding and approving projects with State Health Secretariats.	*I2: "We rely on government resources to execute things. If we plan a project for nurse training on ODT services, it may take a year to transit in the State Health Secretariat. When it's authorized, the project it's outdated."*
Relationships Management • A good relationship among state transplant coordinators allows sharing challenges and success cases, technical or managerial doubts. • A good relationship between state transplant centers and hospitals staff helps to raise awareness on ODT relevance and data compliance within hospital structure.	*I15: "The data coming from hospitals depend on the adherence of the professionals working there, who are not hired or paid to collect and send us the information. It's something that requires time and motivation. So, we have to explain the importance of monitoring ODT results."*
Performance Assessment • ODT performance indicators are a basic management tool, presented in managerial reports to guide decision-making on the need for new investments, educational initiatives, exchange or training employees and tracking goals over time. They also help to motivate and have an evidence-based argumentation with the government, ODT teams and hospitals. • Need for a broader set of mandatory indicators that hospitals and ODT teams must send to state transplant centers. They would allow a more detailed monitoring the performance of ODT activities, at different aggregation levels, such as by team, hospital, state or region. • Need for investments in software and data analysis tools, aiming at new and more detailed analyzes from the state transplant centers database. • Scarcity of time available for discussing and implementing new performance indicators, as a result of insufficient staff the state transplant centers. • Once state transplant centers receive data from different institutions, it is desirable to check for inconsistent or incomplete data, and adopt a standard data collection, processing and analysis format.	I3: *"The indicators give us valuable information to know where the problem is; in a specific hospital or city, at the family interview stage, in the brain death report. From there we can discuss strategies and track results."* I7: *"The numbers are the basis for arguing with hospitals and the government about what needs to be done and the quality of what is being done. They are the embodiment in numbers of what we do."* I8: *"There is a lot of information that would be interesting to have a formal data, like the specific cause of death at hospitals, or the patients' quality of life after transplant. But if it's not a mandatory data, hospitals won't send it to us (state transplant centers), and we cannot track it."*

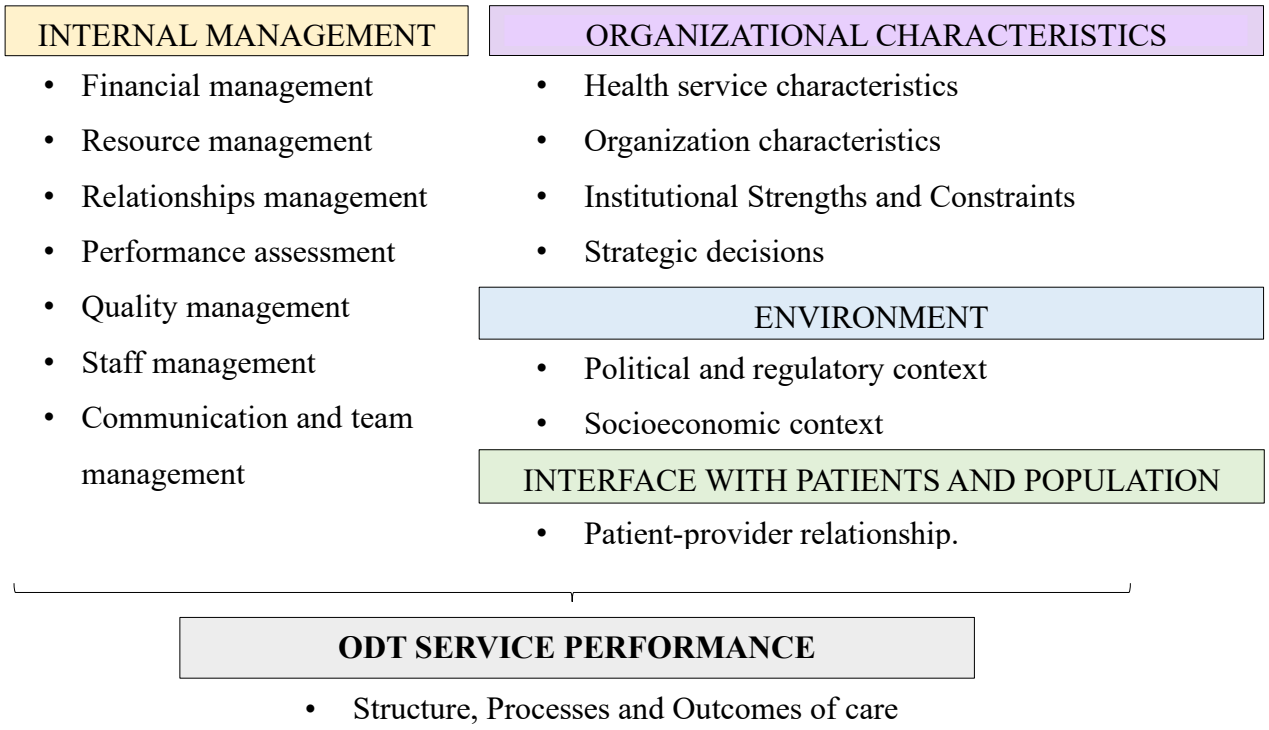
Quality management • Gaps on epidemiological and qualitative data at different stages of the ODT process (e.g. hospitals' specific causes of deaths and donation pool, reasons for family's refusal to organ donation, quality-of-life and adherence to immunosuppressive treatment of transplanted patients).	*I10: "When we see a large number of brain death diagnosis tests and a small number of donations, we search into problems in the diagnosis and maintenance of potential organ donors. Sometimes the hospital or its organ procurement team want to mask something, or they simply do not take data collection seriously. That's why we need to compare information and reason with them."*
Staff management • Lack of a mandatory and standardized training for state transplant coordinator's position, covering managerial activities and specific challenges of ODT field. • Desirable previous experience/training of coordinators with ODT activities or with the management of healthcare services, bringing greater work confidence. • To take the position, coordinators not rarely forsake less challenging and better paying opportunities such as medical practice. • Relevant of technical knowledge for the transplant coordinator position, to understand the operation of the National Health System, the processes, physiology and legislation of ODT services and its state-level political peculiarities. • Coordinators' interpersonal profile compatible with ODT activities, such as empathy and altruism. The solidarity dimension of ODT seems to mitigate practical obstacles, such as scarce financial incentives and long workhours. • Proactivity and intrinsic motivation of the state transplant coordinators, to go beyond what is formally demanded by the Ministry of Health, to seek new ways of solving problems and a continuous professional development. • The large demand of unpredictable tasks, combined with a reduced staff number, requires personnel to get involved in many operational and bureaucratic functions, with little time left for establishing professionals' individual assessment. • Staff turnover at hospitals and ODT teams requires new efforts of the state transplant centers to train and motivate all actors involved in the ODT processes.	I8: *"Although all my training background is in the medical field, this position (of state transplant coordinator) involves managerial skills and knowledge. I had to study a bit of management so I could live up to my work challenges. I took hospital administration courses, and it gave me tools to be a better coordinator. But this is self-initiative, no one told me I would need it."* *I3: "As we have few employees, everyone has to do everything... everyday problems, bureaucratic issues. I think that we (at state transplant center) could benefit from having more people involved, so that we have more time to work effectively on strategic issues."* I6: "*We solve doubts of the general public and specific groups as patients on dialysis, patients on the waiting list, families of deceased donors. We answer questions in our website, by e-mail, phone calls. We help organizing promotional material and events on ODT themes"*
Communication and team management • Desirable relational, political and human resources skills for state transplant coordinator position, aimed to form, motivate and train efficient teams, as well as to present interlocution to interact with a wide network of actors and institutions.	I9: *"A good coordinator has to be tactful. We deal with executive and legislative representatives, state health secretaries, hospital directors, nurses, doctors, patient associations, other coordinators, journalists, patients and families from all range of economic levels..."*
Topic: Organizational characteristics	Transplant Coordinators' quotes

Health services characteristics • The positive reputation of SNT, as SUS public policy that is backed by transplant laws and reliable institutions, ensure its sustainability.	I7: " *SNT has a great reputation, as a serious and effective system in the procurement and distribution of organs and tissues for transplantation. Those working in the frontline of services have to maintain that.*"
Organizational characteristics • Bigger and more experienced state transplant centers tend to present greater expertise in managing ODT services and building relationships within the SNT.	I9: "*Bigger transplant centers have much to contribute. So that the smaller ones, which are still taking baby steps in some points, don't repeat mistakes overcame by others*."
Institutional Strengths and Constraints • Hospitals' approach towards non-absolute contraindications to donation and top management support towards ODT activities can impact its potential donor pool. • Hospitals' approach towards organ donation activities, with non-formalization of the work of donation teams within hospital structure. The lack of financial incentives and clear goals to be fulfilled on ODT can also affect donation results.	I5: "*We need to keep frequent contacts with hospitals, so that doctors, nurses, donation teams, top management, everyone understand the importance of ODT activities. They are not hired or paid by us, but we need them for having good results in our state."*
Strategic Decisions • Greater public-private partnerships could lead to improved capacity and infrastructure of Brazilian hospital network. This requires the National Health System's reimbursement for ODT activities to be attractive for private hospitals..	I11: "*Doctors in public hospitals are not paid for the transplant surgery, that is a very complex procedure. Private hospitals also have little motivation to perform transplant surgeries, because of how much SUS pay them for the procedure*."
Topic: Environment	Transplant Coordinators' quotes
Political & Regulatory context • Political instability, with the exchange of health secretaries and their teams, demand efforts to rebuild relationship networking with the state government. • Since ODT services are closely regulated, there is a great work demand in the state transplant centers involving legal and bureaucratic issues. This leads to reduced time availability for strategic planning and long-term issues.	I2: "*Political changes compromise our work. When a new State Health Secretary comes in, we need to rebuild relationships and have new acquaintances in the State Health Secretariat. We need to show who we are and the relevance of our work, to, only then, ask for help*. "
Socioeconomic context • Concentration of hospital infrastructure within capital cities requires that patients in the waiting list travel to perform the mandatory pre-transplantation exams. • Socioeconomic differences between Brazilian states and regions commonly translate into different degrees of public investments and hospital infrastructure, reinforcing healthcare contrasts in performance.	I14: "*We sent social workers to check what conditions the patient would find after transplantation. The patient lived with ten people in a one-room house, in a street that floods when it rains. The post-transplant would not be safe. Then, through "My Home my Life" housing project, we found a new home for the patient before the surgery*."
Topic: Interface with patients and general population	Transplant Coordinators' quotes

Patient-provider relationship • Poor familiarity regarding the functioning and benefits of ODT services negatively impact families consent to organ donation. This requires education investments, awareness campaigns and media coverage on ODT theme. • Patient dissatisfaction with healthcare provided at public hospitals negatively impact families' decision to organ donation. The poor infrastructure and lack of resources also hampers a timely identification of potential donors.	I5: "*It's hard to raise awareness on the importance of ODT activities amongst overloaded health professionals, who can barely meet patients' basic needs. I realize that sometimes the family's refusal to organ donation is related to the unsatisfactory care delivered. It makes them feel as they are not a priority in the healthcare process, or as they have not received sufficient information*."

Source: Developed by authors

Figure 1. Influencing factors of performance in ODT services



Source: Developed by authors

Figure 2. Managerial recommendations for improving ODT services performance

INTERNAL MANAGEMENT

Financial management:

- Review hospital and professional **payment-system** for ODT procedures.

Resource management

- Streamline **purchasing and bidding processes** at the State Transplant Centers.

Relationships management

- Promote guidelines for a **cordial and steady relationship** between state transplant centers and the hospital teams performing ODT services.

Performance assessment

- Promote **new and more detailed performance indicators** on areas with mapped knowledge-gap (e.g. pos-transplant quality of life), resulting in the adoption of a **broader set of indicators** to be mandatorily reported by hospitals.
- Institutionalize **data management practices**, including standardized data check procedures.
- Government investments on ODT **data systems** with sophisticated data analysis tools and are integrated in the state and national levels.
- Establishment of **goals and agreements between hospitals performing ODT and the respective state transplant center**, aiming structured support and accountability for ODT results.

Staff management

- Revise **staff dimensioning** at hospitals performing ODT and at state transplant centers.
- Promote initiatives to **reduce staff turnover** at ICUs, ODT teams and transplant centers, reducing duplicate training and network efforts.
- Revise **financial/non-financial incentives for ODT professionals**, so their position is not seen as an abdication of more profitable and less demanding professional opportunities.
- Establish **prerequisites for the state transplant coordinator position**, covering:

  a. Formal and standardized training;

  b. Prior experience with ODT processes or health services management;

c. Up-to-date knowledge on specificities of SUS, SNT, ODT and its legislation.

Communication and team management

- Clarify **desirable skills for the state transplant coordinator position**, covering
  a. Relational, political and people management abilities;
  b. Interdisciplinarity, teamwork and personal traits of empathy;
  c. Availability to an intense work, with low predictability of demands
- Promote periodic meetings among state transplant coordinators, aiming a **benchmark of experiences and practices among states** with prominent versus modest ODT results.

ORGANIZATIONAL CHARACTERISTICS

Strategic decisions

- Promote further **partnerships between SNT and the private hospital network**, aiming better healthcare infrastructure for ODT activities.

ENVIRONMENT

Socioeconomic context

- Reassess **hospital infrastructure** investment needs among states and capitals, aiming to reduce healthcare inequalities.

Political and regulatory context

- Secure a **stable political-will towards ODT activities**, regardless of changes in State Health Secretariats.

INTERFACE WITH PATIENTS AND GENERAL POPULATION

Patient-provider relationship

- Intensify **public awareness and educational campaigns** on ODT.
- Clarify hospitals' clinical staff on the relevance of **humanized healthcare** and its impact on family consent for organ donation.

Source: developed by authors

The research contributes to the healthcare literature by shedding light to a scarcely explored theme, especially in the context of developing countries such as Brazil. More specifically, this is the first study to investigate the perspective of State Transplant Coordinators towards the multiple and simultaneous aspects affecting ODT services. When brought together, such factors take on the managerial complexity of this healthcare field, offering a comprehensive framework to be considered for managing and improving ODT processes. The results also allowed drawing a set of recommendations. Thus, by focusing on the managerial challenges and opportunities, it is expected that the findings presented here encourage the discussion and updating of managerial strategies and practices applied to ODT activities.

As for a practical application, this study aims to be useful for healthcare managers, policy-makers, practitioners and researchers, by providing a common agenda that considers manifold aspects not yet jointly addressed in the ODT field.

Despite its contributions, some limitations of this study are worth mentioning. An inherent limitation of qualitative research is the subjectivity in the responses of retrospective questions, based on what the participants recall about the phenomenon (Anderson, 2010). Additionally, interviewees perceptions about what factors affect ODT services performance often reflects their individual experience rather than a general view. Thus, it does not allow the generalization of results to a larger population. Interviews are also prone to subjectivity and bias due to the interviewer direct interaction with the subjects of the study. This data collection method relies to a great extent on the skills and expertise of a trained researcher to undertake interview and interpret its results (Berg & Lune, 2011).

Lastly, this study aims to lay the groundwork for further research, encouraging additional enquiries on the topic. Subsequent studies can examine factors that impact the performance of ODT services in other developing countries, or in developed countries, considering its cultural and socioeconomic idiosyncrasy. It can also be extended by addressing the perspective of other relevant stakeholders and institutions of ODT field. Further research may deepen in the role of one of the factors here presented, or, examine the identified factors considering other ODT settings or distinct health services.

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5. FIRST SUPPLEMENTARY ARTICLE – Brazilian Healthcare Professionals: A Study of Attitudes Toward Organ Donation.

Status: Published.

Journal: Transplantation Proceedings (TP).

Authors: Araujo, C.; Siqueira, M.

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Journal metrics: H-index: 77. 2018 Impact Factor: 0.959

Abstract

Background. Healthcare professionals have a crucial role in organ donation and transplantation processes. Their attitude toward organ donation can affect public opinion and the donation decision made by deceased donors' relatives. The objectives of the study were to analyze the attitude of medical and nursing personnel toward deceased organ donation in two hospitals in Rio de Janeiro, Brazil, and the factors that can affect this attitude.

Methods. A random sample (n = 162) was selected from the population of nurses and physicians in the hospitals analyzed. The sample was stratified by age, sex, marital status, religion, professional category, and educational level. A validated questionnaire addressing psychosocial aspects of organ donation was used to evaluate attitudes. The $\chi 2$ and Mann-Whitney U tests were applied for statistical analysis.

Results. Of personnel surveyed, 86.4% (n = 140) were in favor of deceased organ donation, whereas 11.1% (n = 18) were not sure and 2.5% (n = 4) were against. The favorable attitude was related to the following aspects: (1) educational level, (2) having spoken with family members about organ donation, (3) having a chronic disease, (4) favorable attitude of one's family, (5) belief that organ donation can save lives, (6) concerns about body manipulation, illegal trade of organs, and organ donation being against God's will, (7) feeling proud of working with organ donation/transplantation, (8) self-assessment of experience and knowledge in organ donation/transplantation activities ($P < .05$).

Conclusions. Although organ donation is well accepted among most healthcare professionals surveyed, the results indicate an opportunity for improvements in the awareness of physicians and

nurses who had an indecisive or negative attitude. Additionally, a positive attitude seems to be related to socio-personal variables. The associations observed show the importance of encouraging discussions about organ donation in the family environment, for both healthcare professionals and general population. By providing proper training and motivation, thus clarifying doubts and concerns based on lack of information, professionals are empowered with technical and social capabilities that enhance the confidence to work with ODT activities.

Keywords
Organ donation and transplantation; Attitude; Healthcare professionals.

5.1. Introduction

Organ donation and transplantation (ODT) are activities of great social relevance, saving lives and ensuring quality of life for many people [1]. However, the shortage of organs is a persistent obstacle worldwide and may be affected by human inefficiencies in the process [2-5]. Professionals involved in ODT activities such as physicians and nurses are in direct contact with potential donors and their families and are responsible for the identification and notification of brain death and for the medical support to potential donors. Thus, they can prevent the loss of potential donors and affect the rates of family refusal to donate organs [6-11]. The attitude of physicians and nursing personnel about the ODT process is regarded in many studies as a positive effect on the mindset of the population toward organ donation [12-15].

Despite the influence of healthcare professionals on patients, patients' families, and public opinion [16-18], few studies have been developed in Brazil about the attitude of these professionals toward organ donation [19,20]. No articles were found that addressed professionals who work in hospitals of Rio de Janeiro [21]. Therefore, the objective of this study was to analyze the attitude toward deceased donation and transplantation among physicians and nursing personnel in two hospitals in Rio de Janeiro and to evaluate factors that affect this attitude.

5.2. Methods

5.2.1. Study population

The study was conducted in two Brazilian public hospitals located in Rio de Janeiro with active programs of deceased organ donation and transplantation. The two hospitals (Getúlio

Vargas and Adão Pereira Nunes) have neurosurgery service and a large number of deaths from neurological causes. From the total notifications of brain death registered in Brazil in 2014 (n = 869), almost 20% (n = 169) occurred in these two hospitals. A representative sample of physicians and nurses (n= 162) was randomly obtained. The study's objectives were explained to the respondents, who signed a term of free informed consent, allowing the use of data obtained in the questionnaire.

The population considered is of 1484 healthcare professionals (663 nurses and 506 physicians), and the respondents were restricted to professionals who work in urgency/emergency sectors and in intensive care units. Considering that these professionals are in high demand in these sectors, the time available to participate in the research is a limiting factor to the sample size. In turn, the greater difficulty to access physicians contributed to the lower proportion of this professional category among respondents. However, it is worth noting that the Chi-square test does not require large samples to provide accurate results [22].

5.2.2. Study Variables and statistical Analysis

Professionals' attitudes toward ODT were evaluated through the use of a validated questionnaire addressing psycho-social aspects of organ donation [23-29]. The distribution and collection of the questionnaires was carried out in randomly selected work shifts by nursing supervisors at each hospital. These professionals served as representatives in each hospital, and they received detailed explanations about the research. The survey was self-administered and completed anonymously from August to October 2014.

The dependent variable is the respondents' opinion about deceased organ donation. The following factors are the independent variables: (1) socio-cultural variables such as marital status, sex, age, religion, level of education; (2) work variables such as professional category and pride in working with organ donation; (3) personal beliefs, such as seeing organ donation as an act of solidarity and considering the shortage of organs a serious problem in Brazil; (4) concerns about donation being against the will of God, about the donor's body integrity and its manipulation after death, and about existence of an illegal trade of organs in Brazil; (5) having a chronic disease; (6) having spoken about organ donation within the family and the attitude of family toward organ donation; and (7) self-assessment of experience and knowledge in ODT activities.

The Chi-square and Mann-Whitney U tests were applied for bivariate analysis, with the use of SPSS statistical package version 17.0. The Fisher test was used when contingency tables had cells with an expected frequency <5. Descriptive analysis was carried out for each independent variable at a 5% level of significance.

5.3. Results

Most respondents (n = 140 [86.4%]) had favorable attitudes toward donation of their own organs after death. The others were against (n = 4 [2.5%]) or were not sure (n = 18 [11.1%]). As shown in Table 1, respondent sex, marital status, age (mean [SD]), religion, and professional category did not significantly affect the attitude toward deceased organ donation. Similarly, there were no differences related to the belief that organ donation is an act of solidarity or that shortage of organs is a serious problem in Brazil (P > .005).

In contrast, there were differences according to professionals' level of education. The attitude toward ODT was more favorable among post-graduation respondents in comparison to those with no graduation (97% vs 83%; P = .005). Other variables that affected attitude were having a chronic disease (87% vs 76%; P = .037) and having spoken about organ donation with family members (95% vs 63%; P< .001). Also, the family attitude toward organ donation appeared to affect professionals' attitudes (89% vs 76%; P < .001).

The attitude was more favorable among respondents who believed that organ donation can save lives (87% vs 67%; P = .016), that organ donation is not against God's will (89% vs 37%; P < .001), and were proud of working in cases of organ donation (90% vs 65%; P = .014). Attitude was also more favorable among professionals who were not concerned about organ donation defacing the donors' body (91% vs 70%; P<.001), about body manipulation after death (93% vs 45%; P < .001), and about illegal trade of organs (91% vs 18%). Also, respondents who self-assessed their level of experience (91% vs 79%; P = .022) and knowledge (94% vs 72%; P = .031) in ODT activities as extensive had a more favorable attitudes toward organ donation than those who self-assessed their experience and knowledge as limited.

5.4. Discussion

In activities of ODT, it is crucial recognizing, measuring, and dealing with healthcare professionals' attitudes. These professionals are involved in the identification, notification, and

maintenance of potential donors in approaching the family as well as others fundamental tasks relative to an efficient donation process [4,6]. The scarcity of Brazilian studies regarding variables associated with positive attitudes of healthcare professionals toward organ donation is worth noting. For this reason, the study can enrich the academic literature and encourage new investigations on the issue, in the context of Brazilian hospitals.

Nursing and medical staffs are dominant categories in studies of healthcare professionals' attitude toward ODT [6-11]. The larger contact (and therefore greater influence) of these professionals with potential donors and their families may suggest a reason for this preference. Although many studies show a more favorable attitude of physicians, when compared with other healthcare professions (including nursing personnel) [14-17,30], this result is not a consensus in the literature because there are studies that do not demonstrate significant differences in attitudes between physicians and nurses [31,32]. Likewise, in this study, the professional category did not significantly affect the attitudes toward deceased organ donation.

Also, the results indicate an opportunity for improvements in the consciousness of physicians and nurses because 13.6% of the professionals analyzed had an indecisive or negative attitude toward deceased organ donation. In the present study, the results showed that most professionals with favorable attitudes presented higher levels of education, greater presence of chronic disease, and had the perception that organ donation can save lives and it is not against God's will. They also had spoken with their family about organ donation, and they acknowledged a positive attitude of their family toward organ donation. Additionally, the favorable group felt proud of working with organ donation, felt more capable to perform related activities (in terms of experience and knowledge), and were less fearful about body manipulation after death, illegal trade of human body, and defacing of donor' body.

The associations observed show the importance of encouraging discussions about organ donation within the family and providing proper training and motivation. By clarifying doubts and eliminating concerns based on lack of information, professionals are empowered with technical and social capabilities that enhance the confidence to work with ODT activities.

Table 1. Factors Associated with Attitude Toward Deceased Organ Donation

Variable	Favorable to Organ Donation n = 140 (86.4%)	Not Sure/ Against Organ Donation n = 22 (13.6%)	P Value
Sex			
Male (n = 64)	54 (38.6)	10 (45.5)	.539
Female (n = 98)	86 (61.4)	12 (54.5)	
Marital status			
Single (n = 78)	68 (48.6)	10 (45.5)	.780
Married (n = 72)	61 (43.6)	11 (50)	
Divorced/separated/widowed (n = 12)	11 (7.9)	1 (4.5)	
Age			
Mean (SD) age, years (n = 69)	34 (8)	35 (9)	.293
Religion			
Catholicism (n = 67)	57 (40.7)	10 (45.5)	
Spiritism (n = 21)	19 (13.6)	2 (9.1)	.597
Evangelism (n = 27)	24 (17.1)	3 (13.6)	
Others (n = 22)	17 (12.1)	5 (22.7)	
Did not answer (n = 25)	23 (16.4)	2 (9.1)	
Professional category			
Physician (n = 51)	49 (35)	2 (9.1)	.052
Nurse (n = 110)	91 (65)	20 (90.9)	
Educational level			
Post-graduation (n = 34)	33 (23.6)	1 (4.5)	.005*
Higher education (n = 128)	107 (76.4)	21 (95.5)	
Have spoken with family members about organ donation			
Yes (n = 119)	113 (80.7)	6 (27.3)	.000*
No (n = 43)	27 (19.3)	16 (72.7)	

Have a chronic disease			
Yes (n = 13)	10 (7.1)	3 (13.6)	.037*
No (n = 149)	130 (92.9)	19 (86.4)	
Family is favorable to organ donation			
Yes (n = 141)	124 (88.6)	17 (77.3)	.000*
No (n = 21)	16 (11.4)	5 (22.7)	
Organ donation is an act of solidarity			
I agree (n = 148)	129 (92.1)	19 (86,4)	.105*
I disagree (n = 3)	2 (1.4)	1 (4,5)	
DK/NA (n = 11)	9 (6.5)	2 (9,1)	
Organ donation can save lives			
I agree (n = 149)	130 (92.9)	19 (86.4)	.016*
I disagree (n = 6)	4 (2.9)	2 (9.1)	
DK/NA (n = 7)	6 (4.2)	1 (4.5)	
Shortage of organs is a serious problem in Brazil			
I agree (n = 131)	118 (84.3)	13 (59.1)	.084*
I disagree (n = 10)	8 (5.7)	3 (13.6)	
DK/NA (n = 21)	14 (10)	6 (27.3)	
Organ transplantation is against the will of God			
I agree (n = 8)	3 (2.1)	5 (22.7)	.000*
I disagree (n = 143)	128 (91.4)	13 (59.1)	
DK/NA (n = 11)	9 (6.4)	4 (18.2)	
Organ donation can deface donor’s body			
I agree (n = 20)	14 (10)	6 (27.3)	.000*
I disagree (n = 134)	122 (87.1)	12 (54.5)	
DK/NA (n = 8)	4 (2.9)	4 (18.2)	
Concerned about body manipulation after death			
Concerned (n = 22)	10 (7.1)	12 (54.5)	.000*
Not concerned (n = 132)	123 (87.9)	9 (40.9)	

DK/NA (n = 8)	7 (5.0)	1 (5.5)	
I am proud to work in cases of organ donation			
Yes (n = 137)	123 (87.9)	14 (63.6)	.014*
No (n = 17)	11 (7.9)	6 (27.3)	
DK/NA (n = 8)	6 (4.3)	2 (9.1)	
Illegal trade of human organs exists in Brazil			
I agree (n = 47)	37 (26.4)	10 (45.4)	. 049*
I disagree (n = 102)	92 (65.7)	10 (45.4)	
DK/NA (n = 13)	11 (7.9)	2 (9.1)	
Self-assessment of experience in ODT activities			
Extensive (n = 94)	86 (61.4)	8 (36.4)	.022*
Moderate (n = 7)	6 (4.3)	1 (4.5)	
Limited (n = 61)	48 (34.3)	13 (59.1)	
Self-assessment of knowledge in ODT activities			
Extensive (n = 63)	59 (42.1)	4 (18.2)	.031*
Moderate (n = 81)	68 (48.6)	13 (59.1)	
Limited (n = 18)	13 (9.3)	5 (22.7)	

Abbreviations: DK/NA, do not know/not answered; ODT, organ donation and transplantation.

**Significance at 5% or 1% level.*

Another key point is the awareness about the benefits of organ donation (for the family, as an opportunity to transform a great loss in an act of solidarity; for the receptors, in terms of survival and improvement of quality of life; and for the national health system, that transplantation may represent the most cost-efficient treatment and may provide to patients an economically active life). Last, the propagation of competence and trust among healthcare professionals who work with ODT may positively affect families' decisions on organ donation

5.5.Concluding remarks

In short, the results indicate the importance of training and developing healthcare professionals on the ODT process and the need for public awareness campaigns regarding the importance of donation and process reliability. The results converge with a large body of literature which, based on theories and on empirical studies, indicates a positive influence of attitude on the performance of a voluntary behavior such as organ donation [4,7,17,18,20,22].

This study may be useful for academic purposes (enriching the scarce literature of Brazilian studies regarding attitudes of healthcare professionals toward organ donation) and for hospital managers (providing awareness of possible factors associated with attitude of physicians and nurses toward deceased organ donation).

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6. SECOND SUPPLEMENTARY ARTICLE – Innovations in Organ Donation and Transplantation Services: A Systematic Literature Review

Status: Published.
Journal: RAHIS, Revista de Administração Hospitalar e Inovação em Saúde.
Authors: Siqueira, M.
Journal information: The purpose of the journal is to publish and disseminate by electronic means, free of charge, theoretical and applied research that fosters knowledge in the area of Hospital Administration and the Health Sector.
Journal metrics: CAPES: B3

Abstract

Organ donation-transplantation processes are highly complex and have significant potential for improvements brought by innovations. This article aims to summarize the literature addressing innovations on donation-transplantation services, analyzing the types and focus of innovations and describing research gaps and opportunities. A systematic search was performed on health and management databases, applying descriptors that integrate innovation and donation/transplantation themes. From 115 articles initially returned, 31 were analyzed. The results indicate concentration of studies in the United States and addressing the transplantation of kidneys or livers from deceased donors. Most are empirical studies, predominantly clinical trials. In general, innovations are measured from their effects on a group of individuals and are distributed in the various stages of the donation/transplantation process. It has become evident that innovations in the field are analyzed mainly under a clinical spectrum, through the description of the innovation and its medical results. The scarcity of discussions about the management of the innovation process makes room for future research.

Keywords

Systematic Review. Innovations. Organ Donation and Transplantation.

6.1.Introduction

A systematic review on economic assessments in organ transplantation has brought empirical evidence that, in general, the costs of this therapeutic option have decreased over time. Additionally, the recipients' survival and quality of life have increased (Tritaki, Di Giannantonio & Boccia, 2014). However, the changes are mainly attributed to medical advances, with no management or innovation aspects being addressed. Considering the social relevance (Mahíllo & Marazuela, 2017; Westphal et al., 2011) and the complexity of organ donation-transplant services (Beyar, 2011), the mapping of what they are and how innovations occur in this health field can offer insights on quality, efficiency and cost-effectiveness improvements.

There are numerous definitions for the innovation construct (Baregheh, Rowley & Sambrook, 2009), which can be described as the systematic adoption of new ideas in products, services or organizational processes (Thompson, 1965; Ettlie & Reza, 1992). These innovations can be radical or incremental. The first category creates something totally new by destroying old competencies, while the second one improves competencies and adds changes to the existing product, service or process (Henderson & Clark, 1990).

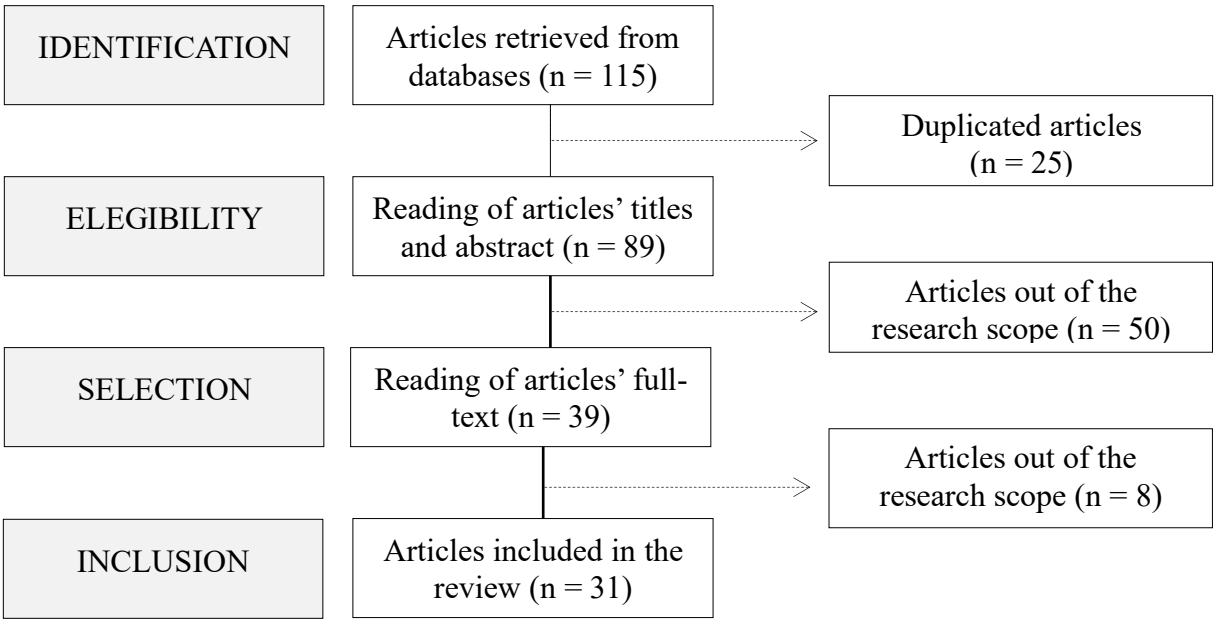
While other works have already proposed to analyze innovations in the health sector (Moullin, Sabater- Hernández, Fernandez- Llimos & Benrimoj, 2015; Chaudoir, Dugan & Barr, 2013; Länsisalmi, Kivimäki, Aalto & Ruoranen, 2006), a systematic review of innovations applied to ODT services was not identified so far. As an scarcely explored topic, there is great potential for identifying gaps and opportunities for future research. Innovations in this field may allow, for example, to address efficiency and effectiveness issues, providing better results in the extracorporeal maintenance of donated organs, expanding the pool of viable donors, or allowing improvements in the survival and quality of life of transplant recipients (Länsisalmi et al., 2006).

This systematic review aims to describe the literature on innovations applied to ODT services. To do so, in addition to analyzing descriptive categories, such as the research year, country, study design and journal of publication, innovations are classified by their development stage and focus, whether on clinical or managerial aspects. Such categorizations allow a common basis for comparison among selected studies. The systematic review enables the mapping of research gaps, such as methodological weaknesses and poorly explored topics, aiming to be useful to researchers and managers in the areas of innovation and health services.

6.2.Methods

The research method employed was the systematic review, as it allows the identification and synthesis of academic literature on specific topics, following standardized steps that provide reliability and scientific rigor and make it possible the research replication (Botelho, Cunha & Macedo, 2011). The search was carried out in January 2017, in the Virtual Health Library (BVS), Science Direct and Web of Science databases. The BVS repository also includes LILACS, MEDLINE and PAHO databases. The scholarly databases cover the health and management fields and were chosen or their accessibility and relevance, being commonly used in health management systematic reviews. The descriptors ("innovation" or "innovator") and ("donor" or "donation" or "transplant" or "transplantation" or "organ transplant" or "organ donation"), in English or Portuguese, should be contained in the studies title. Academic articles, published in journals, with full text available in Portuguese or English were selected. The time frame was from 2006 to 2016, portraying a decade of academic production.

Figure 1. Selection of studies included in the systematic review



Source: Based on PRISMA Flow Diagram (Moher, et al., 2009)

This review follows the guidelines presented by Moher et al. (2009), as summarized in Figure 1. The databases search initially returned 115 studies. The basic information of these studies (such

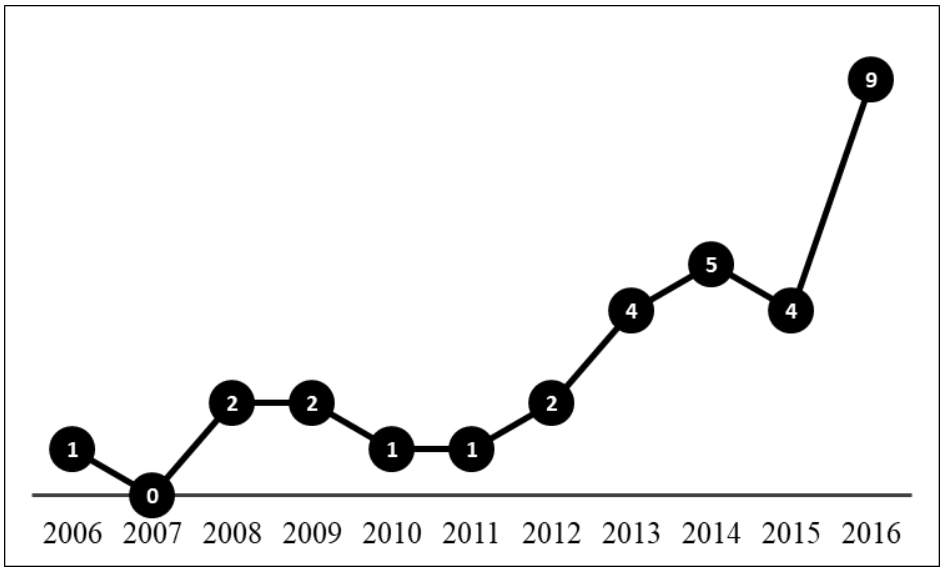
as authors, title and year of publication, journal and keywords) were exported, through the Endnote software, to an Excel spreadsheet, starting the data mining process. After removing 25 duplicated studies, returned from more than one database, the title and abstract of 89 studies were assessed, leading to the exclusion of 50 studies. These studies were deemed out of the research scope for not addressing solid organs. Thus, articles focusing on stem cell, hair, blood or skin grafts donation-transplantation were excluded. Non-empirical articles, such as editorial letters, were also excluded. The next step was the full-text reading of the remaining 39 articles. This led to the exclusion of 8 studies that, despite addressing solid organ donation-transplantation, did not present innovations as their main topic. This resulted in the inclusion of 31 articles in this review.

6.3.Results

6.3.1. Descriptive results

As shown in figure 2, the annual number of publications on the targeted topic is limited and presents significant fluctuation over the period of analysis. There is an increase in the number of publications since 2012, especially in 2016, suggesting a growing academic interest in the topic.

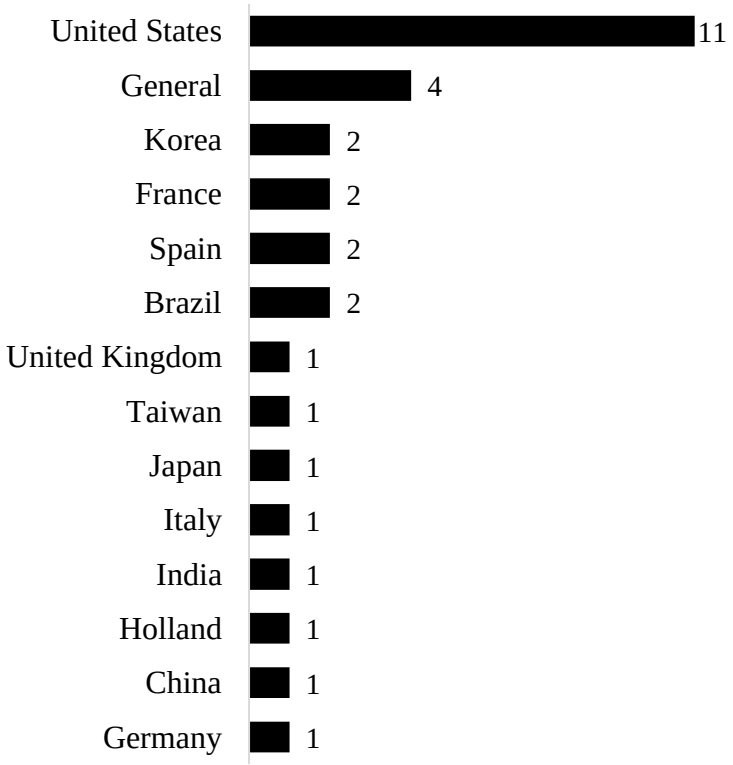
Figure 2. Publications per year



Regarding the research country, there is a clear concentration of studies (n = 11) carried out in the United States, a country of global economic relevance, also standing out in the results and investments made on ODT services. Few studies (n = 4) do not have a defined research country

(due to lack of information or because it is a theoretical study with no geographic boundaries). The remaining studies (n = 16) were conducted in 12 different countries. Among them, Brazil appears in two studies of the sample. Given the National Transplant System relevance, figuring among the countries with highest absolute number of transplants (RBT, 2018), the result indicates opportunity for researching innovation in the ODT field at the national context.

Figure 3. Publications per research country

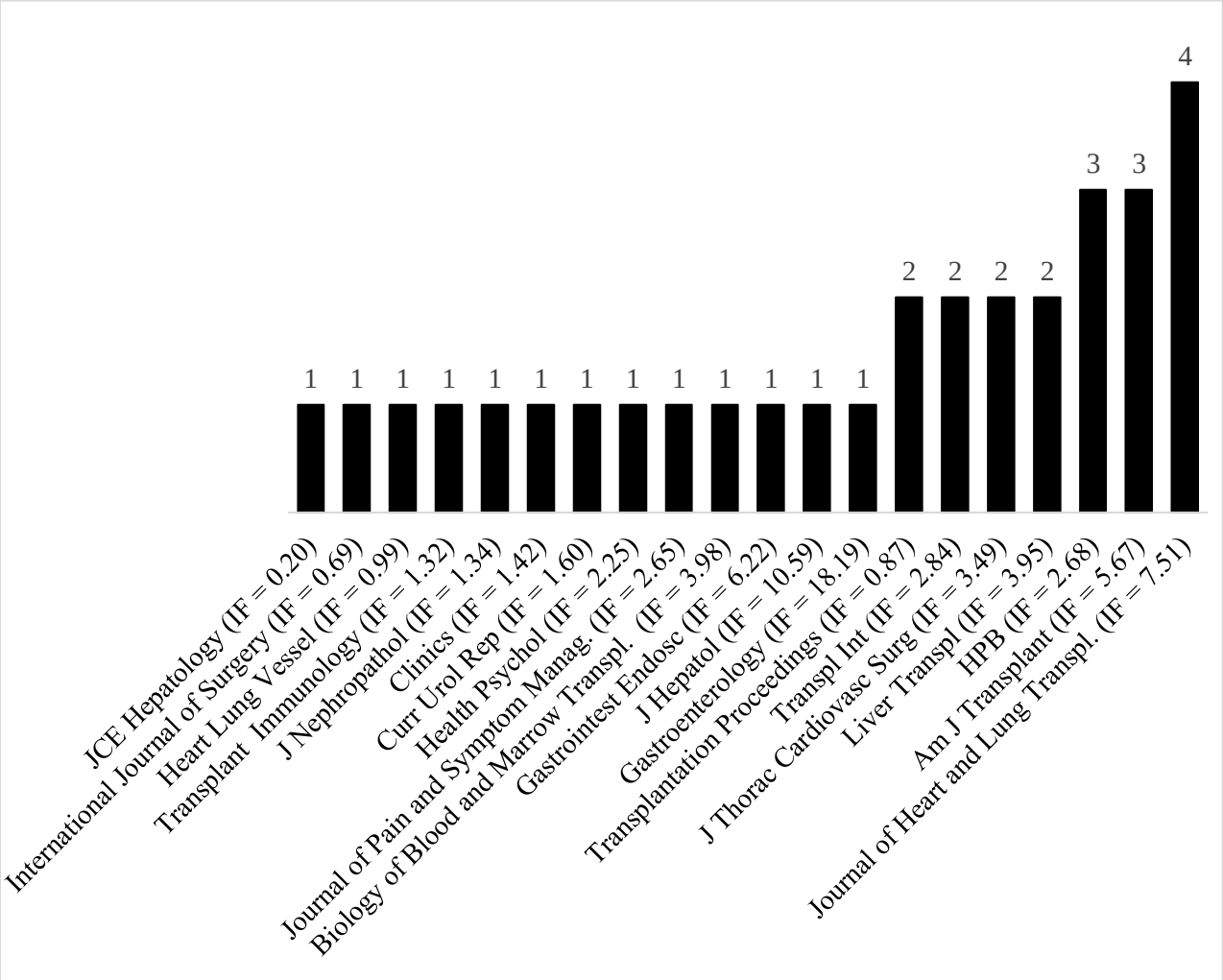


Additionally, as seen in figure 4, the publications are distributed among several journals, with emphasis on The Journal of Heart and Lung Transplantation, American Journal of Transplantation and HPB. Of the 31 studies analyzed, 13 were published in different journals, with a maximum of 4 articles published in the same journal. There is also a high impact factor for journals (mean IF = 2.92). After analyzing the title and scope of the journals identified, although some of them allow publications underlying managerial aspects, they all have a medical focus.

Regarding the studies timeframe, 11 of them are cross-sectional, with data collected at a single point in time, while the remaining 20 articles are longitudinal, allowing to study trends or changes in the characteristics analyzed. Of these, 12 are retrospective (collecting data on facts or

health conditions that occurred in the past) and 8 are prospective (collecting data on facts or health conditions that occur at the present time of the study or that will occur in the future, during the follow-up of the study population). The concentration of longitudinal studies suggests an interest in studying, over time, the results of innovations, which often requires monitoring the health status of patients (users of the innovation) or to track the result indicators of donation-transplant activities in a particular location.

Figure 4. Articles per academic journal

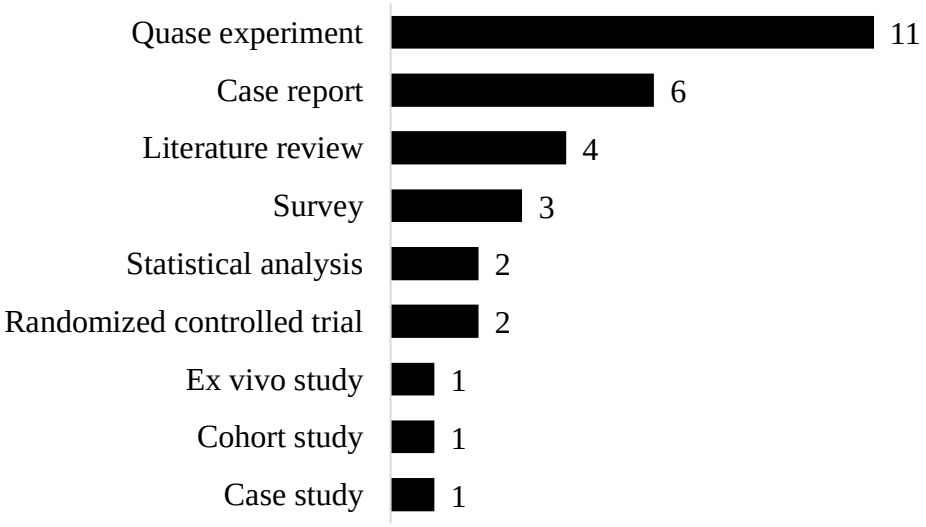


Regarding the research method (figure 5), innovation in ODT is studied from different perspectives and methodological tools. Of the 31 publications analyzed, 4 are literature reviews describing and qualitatively discussing the innovation analyzed, which includes strengths, ethical

issues, possible obstacles to its adoption and diffusion, among others. The remaining articles are empirical and use primary data. The prevalence of empirical studies shows the practical nature of ODT activities, often analyzed through epidemiological studies with direct observation of patients.

There is a concentration of study designs as clinical trials and case reports. The first one tests the innovation effectiveness through an intervention in the studied population, examining patients' clinical results before and after the preventive or therapeutic intervention with a new medication or surgical technique related to ODT services. This type of study follows a scientific rigor that contributes to the discovery of several therapeutic innovations, unknown diseases and side effects (Kienle & Kienle, 2011).

Figure 5. Publication per research method

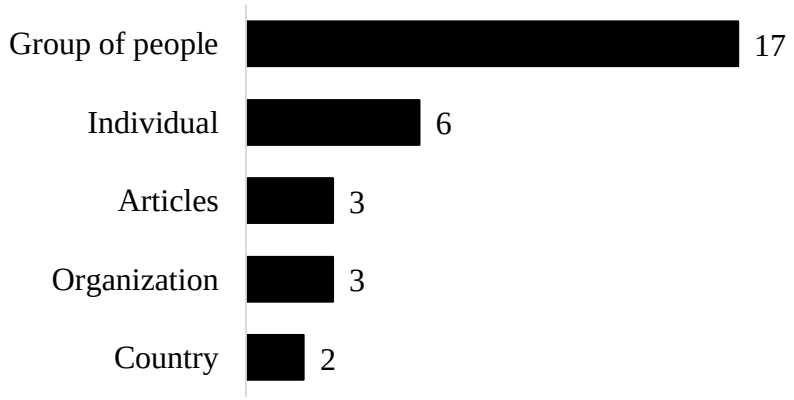


Is worth mentioning that only 2 of clinical trials are randomized clinical trials (RCTs), with participants randomly allocated to placebo or intervention groups. This type of study allows controlling variables in order to identify cause-effect relationships and is considered the method with the greatest methodological prestige in the scope of Evidence-Based Medicine. On the other hand, they demand more time and financial resources, which may not be feasible for many studies (Kienle & Kienle, 2011). Other methods adopted include the application of questionnaires, of statistical data analysis, ex vivo and cohort studies. The ex vivo study represents the intervention or experiment carried out on the organ in an external environment, that is, outside the body of its donor and not yet transplanted in its recipient, seeking minimal changes in its natural physiological

conditions. Unlike clinical trials, that have experimental design, cohort studies are observational and to not allocate patients into groups, simply observing and comparing clinical results between an naturally exposed group and a group not exposed to the analyzed intervention.

The vast majority of studies analyzed a group of individuals (patients who participated in the research). In second place are the studies where a single individual is analyzed (as in the case report of an innovative surgical technique, performed for the first time on a given patient). In the theoretical articles, the existing literature (other academic studies) constitutes the analyzed population. Other levels of analysis include an organization (such as results measured at a transplant center or hospital where the analyzed innovation is implemented) or a country as a whole (where, for example, a new model for organ donation or a new criterion for donor selection is being discussed).

Figure 6. Publications by analysis level



Another described aspect was the studies motivation for investigating innovation in the ODT field. The vast majority (n = 26) cited practical problems faced by the population, patients and health professionals. Such problems are easily observed and include shortages of organs and long lines for transplantation, clinical complications in transplant surgery or post-transplantation (causing deaths and loss of donated grafts), failures in the identification and maintenance of potential donors, failures in the hemodynamic maintenance of organs, among others. Other motivations are the existence of research gaps on the topic (n = 3) and the extension or continuation of existing studies (n = 2), seeking complementarity.

As shown in Table 1, publications were also classified within the ODT process. The most analyzed organs were liver (n = 11) and kidney (n = 5), with a smaller number of studies dedicated to other transplantable solid organs. The finding is in line with the fact that kidneys and livers are the most donated and transplanted solid organs around the world, as pointed out in the Global Observatory on Donation & Transplantation report (GODT, 2016). In addition, many articles (n = 8) analyzed innovations that do not require specification of a single solid organ. The innovations are concentrated in some stages of the process, such as donation (n = 9), transplant (n = 8) and post-transplant (n = 7). Steps such as organ removal (n = 3), identification of the potential donor in Brain Death (n = 2) and maintenance of the donor within the clinical conditions compatible with organ donation (n = 1) were less addressed, as well as the storage of the removed organs (n = 1). Finally, most studies deal with innovations compatible with ODT from deceased donors (n = 21), which constitutes most donations in the world (GODT, 2016).

Table 1. Stage of the Donation and Transplantation Process

Study	Process stage	Organs	Donor type
Axelrod et al (2009)	Post-transplant	Kidney, Liver	Deceased
Bastini (2015)	Donation	Kidney	Living
Boston et al (2013)	Transplant	Multiple	Deceased
Wright et al (2008)	Post-transplant	Liver	Deceased
Garcia Valdecasas (2012)	Donation	Liver	Deceased
Siegel (2014)	Donation	Multiple	Deceased
Briceño et al (2014)	Post-transplant	Liver	Deceased
Caso (2014)	Organ procurement surgery	Multiple	Living
Cheng et al (2013)	Post-transplant	Kidney	Living
Gerber e Feng (2014)	Donation	Lung	Deceased
Iwasaki et al (2014)	Transplant	Liver	Living
Lee et al (2008)	Organ procurement surgery	Liver	Living
Michel et al (2015)	Organ storage	Multiple	Deceased
Moon et al (2015)	Organ procurement surgery	Liver	Living

Testa (2009)	Donation	Liver	Living
Arujuna, Ali e Banner (2016)	Potential donor identification	Heart	Deceased
Choudhary et al (2016)	Post-transplant	Liver	Deceased
Compagnon et al (2016)	Potential donor maintenance	Multiple	Deceased
Fryer and Iyer (2006)	Donation	Intestine	Deceased
Gottlieb et al (2013)	Post-transplant	Lung	Deceased
Gottlieb et al (2015)	Post-transplant	Lung	Deceased
Lindstrom et al (2016)	Post-transplant	Multiple	Not specified
Nelson et al (2013)	Transplant	Heart	Deceased
Rea et al (2010)	Donation and transplantation	Lung	Deceased
Renders and Jong (2016)	Transplant	Kidney	Deceased
Sanchez et al (2016)	Post-transplant	Liver	Living (pediatric)
Shores et al (2016)	Transplant	Liver	Deceased
Yucel (2016)	Transplant	Kidney	Deceased
Hassan et al (2011)	Brain Death diagnosis and organ donation after circulatory death	Multiple	Deceased
Sarlo et al (2016)	Donation	Multiple	Deceased
Galvão et al (2012)	Transplant	Anorectal	Not specified

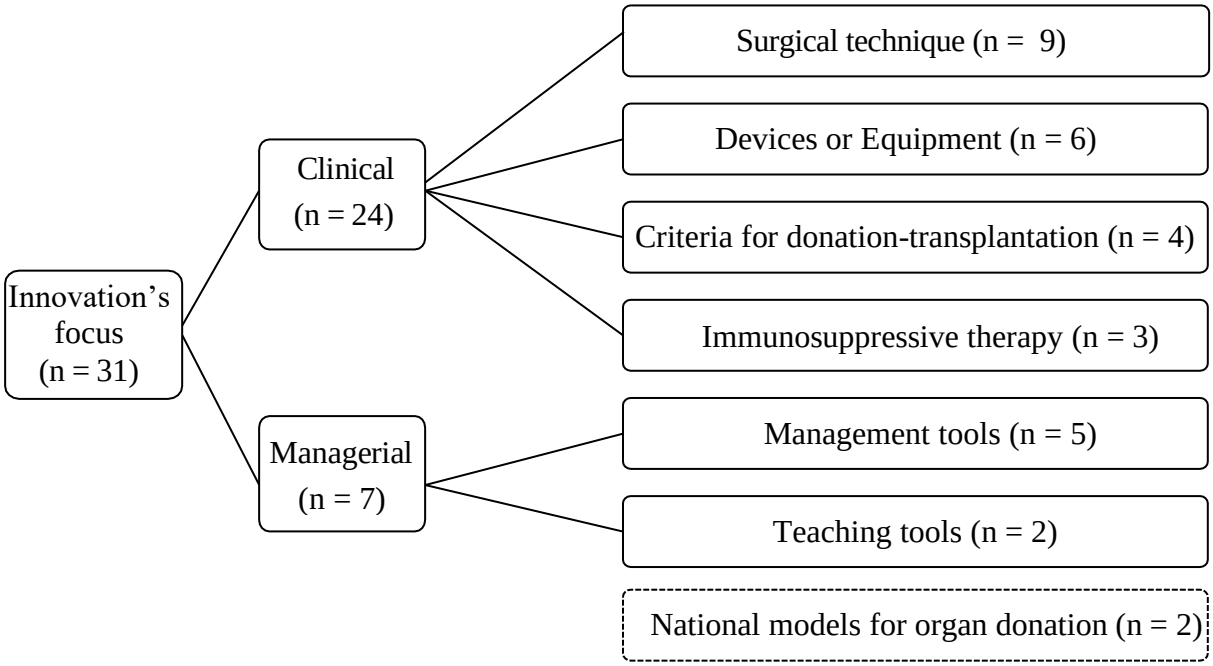
Source: Developed by the author.

6.3.2. Analytical results

As shown in figure 7, the innovations analyzed were categorized by into managerial or clinical and into radical or incremental, referring to the introduction of a totally new or significantly improved product or organizational process (Lager, 2002). The vast majority of innovations presented a clinical focus (n = 24; 77.42%). Within them are surgical techniques and equipment or devices that aim at greater safety and better medical results. These innovations mainly refer to products (such as a new device for transplant surgery or new equipment for

extracorporeal preservation of organs). In general, they are technology intensive, requiring high investments and are often linked to patents and partnerships with other actors and institutions (such as the medical equipment/devices and pharmaceutical industries). Still under a clinical focus, there are innovations related to new medical criteria for selection of donors and recipients and for measuring donor-recipient compatibility. These can be characterized as process innovations. They seek greater safety and a larger pool of compatible donors-recipients, which, ultimately, aims to increase the number of donations and transplants performed.

Figure 7. Innovations' focus



Among the innovations with a managerial focus (n = 7; 22.58%), which are not mainly dependent on medical resources and knowledge, there are teaching tools as an online course or simulation technique for medical education on ODT activities. Another subcategory was named as management tools. As best described in table 2, these innovations include, for example, a management model with the insertion of a new position to coordinate donation activities in the hospital. They also include initiatives as: quality measures to monitor and encourage adherence to vaccination in transplanted patients, application of a lean process to expedite the insertion of patients in the transplant waiting list, and tools to predict and evaluate the results transplant

centers. In this managerial approach, innovations are mostly processes, seeking a more efficient and effective productive process rather than a new or modified product.

External to the managerial and clinical approaches are the national models for organ donation (n = 2), which constitute discussions about public health policies. These can be categorized as process innovations, as they refer to a new way of making organ donations in a country. They include, for example, a national-level proposal for the payment of a fixed cash amount to living donors, and the adoption of a presumed consent donation approach. In this case, if the citizen does not show a willingness against the donation in a legal document, he will be considered an organ donor at death the time of death. It was also observed that the studied innovations are well divided between product innovations (n = 15) and organizational (n = 16) innovations. On the other hand, they were mostly classified as incremental (n = 27), with a smaller number of radical innovations (n = 4) being identified.

As shown in Table 2, another perspective for analysis refers to the stage of the innovation process. Initially, a new product, practice or service is developed in the focal company, constituting the generation stage. After the initial exposure to innovation, the company's efforts are focused on the adoption and assimilation of the new product or process within the organizational environment. Finally, the diffusion phase refers to the dispersion of innovation among a broader system of companies or individuals. Thus, unlike the first two stages, the focus at this stage is extra-organizational (Gopalakrishnan & Damanpourb, 1994; Shepard, 1967). Most articles (n = 17; 54.84%) describe innovations in the diffusion phase, recommending the innovation use in other similar situations (such as a surgical technique, developed in a specific transplant center, currently being adopted by other centers). In second place are the articles (n = 9; 29.03%) that describe innovations in the adoption stage (such as a surgical technique that is still incipient, with a single case report). The other articles (n = 5; 16.13%) analyze innovations in the initial stage of ideas generation (as a possible new national model for organ donation that is still under discussion).

Table 2. Description of Innovations Identified in the Studies

Study	Focus	Innovation description
Axelrod et al (2009)	Adoption	Graphical tool for assessing transplant outcomes and transplant center performance: Risk-adjusted cumulative sum graph.
Bastini (2015)	Adoption	Organ donation model: Fixed amount payment for live kidney donors, based on the Iranian model.
Boston et al (2013)	Adoption	Lung assistance paracorporeal device.
Wright et al (2008)	Adoption	Device for visualizing endoscopic channels in surgeries caused by biliary complications in post-renal transplant recipients: Spyglass Direct Visualization System
Garcia Valdecasas (2012)	Adoption	Donation model: European approach for organ donation, including European Union donor card and presumed consent.
Siegel (2014)	Adoption	Tool for measuring the construct 'attitude' as a predictor of 'behavior' in organ donation: Principle of compatibility
Briceño et al (2014)	Adoption	Donor-recipient correspondence measurement tool: Artificial Neural Networks.
Caso (2014)	Adoption	Minimally invasive surgical technique, using robotics, for live donor nephrectomy.
Cheng et al (2013)	Diffusion	Surgical technique for prevention of arterial complications in living renal donors.
Gerber e Feng (2014)	Diffusion	Immunosuppressive drug therapy after lung transplantation: Albuterol.
Iwasaki et al (2014)	Diffusion	Criterion for graft selection, aiming greater safety of living donors: Comparison of results between donations from the right and left renal hemisphere.
Lee et al (2008)	Diffusion	Surgical technique to reconstruct branches of the hepatic artery in living liver donors.
Michel et al	Diffusion	Hemodynamic organ storage device: Sherpa System.

(2015)		
Moon et al (2015)	Diffusion	Surgical technique for vascular reconstruction at organ removal surgeries.
Testa (2009)	Diffusion	Criterion for selection of living donors: Inclusion of elective surgery patients for laparoscopic cholecystectomy.
Arujuna, Ali e Banner (2016)	Diffusion	Placement of defibrillator and electrocardiogram for patients with heart transplantation undergoing cardioversion of ventricular arrhythmias.
Choudhary et al (2016)	Diffusion	Use of esophageal stent for binding of esophageal ulcer after liver transplantation.
Compagnon et al (2016)	Diffusion	Transportable and oxygenated perfusion equipment to increase the liver donor pool: Airdrive.
Fryer and Iyer (2006)	Diffusion	Criteria for combined intestine and liver transplantation: use of living donors and segmental grafts from deceased donors.
Gottlieb et al (2013)	Diffusion	Comparison between quadruple (innovative) and triple (standard) immunosuppressive regimens after lung transplantation.
Gottlieb et al (2015)	Diffusion	Comparison between quadruple (innovative) and triple (standard) immunosuppressive regimens after lung transplantation.
Lindstrom et al (2016)	Diffusion	Protocol for increasing adherence to vaccination in post-transplantation: Quality measures including computerized medical history of vaccination.
Nelson et al (2013)	Diffusion	Lean process applied to the patient's workflow, aiming to reduce patients' referral time until their inclusion in the transplant list or the implantation of mechanical circulatory support.
Rea et al (2010)	Diffusion	Surgical technique that allows the adaptation of the grafted lung to the size of the rib cage, thus increasing the donor pool.
Renders and	Diffusion	Online course for medical education in kidney transplantation.

Jong (2016)		
Sanchez et al (2016)	Generation	Surgical technique for the treatment of intrahepatic biliary stenosis after pediatric liver transplantation.
Shores et al (2016)	Generation	Surgical technique for expanding the group of living donors in double liver transplantation
Yucel (2016)	Generation	Surgical technique of robotic kidney transplantation with regional hypothermia, a minimally invasive approach for conventional kidney transplantation operation.
Hassan et al (2011)	Generation	Teaching technique, using a high-fidelity scenario simulator, used in the operating room to teach residents and fellows about donation management after cardiac death and discuss the integration of organ donation in end-of-life care.
Sarlo et al (2016)	Generation	Management of organ donation activities in the hospital environment: adoption of the hospital donation coordinator position and of professionals dedicated full-time to organ donation activities.
Galvão et al (2012)	Non-adoption	Surgical technique for anorectal transplant.

Source: Developed by the author.

6.4. Concluding remarks

The analysis of the selected articles indicated that the innovation literature on ODT services has great practical relevance, addressing real problems faced by patients. Despite the scarce number of publications, studies in the field have increased in the last decade, signaling greater interest in the topic.

Innovations were found in the most diverse stages or activities of these health services. However, there is greater concentration in certain stages, such as organ procurement, transplant surgery and post-transplant monitoring. In the meantime, some stages remain poorly studied in terms of innovations, such as the identification, maintenance and removal of organs from the potential donor, and the storage and transport of organs. Such distribution of innovations must pay attention to the possible medical, technological and ethical restrictions existing at each stage

of the process. Even so, it can signal areas poorly explored and that could generate innovative value to the process.

Innovations are also concentrated at certain stages of the innovation process. They are fewer in the initial stages of generation and adoption and more frequent in the diffusion stage, where the analyzed article recommends the use of adopted innovation in other situations. Thus, there is research potential to describe and explore how to make the generation or adoption phases of innovations more efficient. Even after the generation and adoption stage, when the articles encourage the diffusion of the innovation in question, the organizational learning and implementation process necessary for effective change are not addressed (Basadur & Gelado, 2006). None of the articles specifically addressed the implementation of innovation, such as organizational obstacles, phases to be followed or actors involved.

It is worth noting that implementation is the transition period in which the members of the focal organization become increasingly skilled, consistent and committed to using an innovation. That is, they become proficient in the use of the new practice, process, service or product (Birken, Lee & Weiner, 2012). Without the correct implementation, the real benefits of innovation are not realized (Chiu & Fogel, 2016). This requires leadership, support and resource allocation by senior and middle management (Carter et al., 2013; Klein et al., 2001), in addition to acceptance and adoption by other members of the organization (Jasperson et al., 2005).

Additionally, even with the search for articles being carried out in both health and management databases, clinical and technical aspects are predominant, with few articles focusing on innovations with managerial implications and no article on how to manage the innovation process. Such observation is also signaled by the absence of articles published in management journals. Thus, in the described innovations, the use of resources and knowledge from the medical field, rather than managerial tools, is predominant.

Such managerial approach to innovations would allow addressing the use of organizational knowledge and skills to create value and competitive advantages for the organization delivering the ODT services. It also makes it possible to address the organizational objectives of innovation, such as improving the quality, safety and agility of the health service or reducing its costs.

Another interesting issue that emerged from the results was the predominance of incremental innovations, representing products, services or processes that are not totally new or

unprecedented in the sector. As presented in Farias & Vargas (2013), the Schumpeterian and neo-Schumpeterian view is that innovation will not necessarily be abrupt, spontaneous and destabilizing, initiating a process of "creative destruction". The change process can be cumulative and incremental over time. That is, the accumulation of knowledge and experience would be the engines of innovation. Considering financial and regulatory research limitations, the finding signals that there is room for radical innovations in this field. Other identified gaps refer to the innovations impact on economic, social and ethical domains, for healthcare patients, professionals, organizations and systems.

It is also important to mention the limitations of the study. As in any systematic review, there is an inevitable loss of studies indexed in not included databases. This work only analyzed published articles, excluding dissertations, thesis and government reports. Thus, it is recommended that future studies broaden the search scope, including other types of documents. It is also suggested to include the ODT of tissues and cells in the scope of the study, thus covering a larger number of studies. There are also different perspectives or theories for analyzing innovations in health services, such as the logics and trajectories of service innovations, which could enrich and complement the present review.

From complex processes, as ODT services, come significant potential for organizational improvements, including those prevenient from innovations. Expanding the knowledge on what are the innovation in this field, and how they take place, allows to identify areas which innovative potential have not been explored and methodological gaps that could benefit from new studies or new approaches. Thus, this review is intended to be useful for the community of academics, health professionals and managers in both innovation and ODT areas.

6.5. References

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7. CONCLUSIONS

7.1. Findings and contributions

This doctoral thesis focused on the performance of ODT services, especially in the Brazilian context:

- In the first article, the topic is addressed by mapping the indicators employed in the literature to track the performance of ODT activities.
- In the second article, the performance is examined as the conversion of human and physical resources into the number of kidney transplants, considering Brazilian states as unit of analysis.
- In the third article, the factors perceived as enablers of obstacles of performance are explored as perceived by those responsible for managing ODT services in the state-level.
- In the first supplementary article, the attitude of Brazilian medical and nursing personnel towards organ donation is examined, assuming the relevance of a positive attitude to the performance of ODT services.
- In the second supplementary article, considering the innovation potential to improve health services performance, the innovations applied to ODT activities are mapped.

Through a systematic literature review, the first article identified 117 indicators used to measure the performance of ODT activities, suggesting the academic interest in this field. However, the results show that measures vary significantly among studies, both in content and shape. Given the large number and heterogeneity of indicators, many of them without detailed procedures regarding their choice, validation and interpretation, it is important to define which ones are best suited to aid the targeted processes. None of the analyzed studies assessed the quality of indicators employed, in terms of a clear definition, of a standardized measurement format, of access to reliable and pertinent data, of content validity, of viability in terms of time, financial and human resources involved in its measurement, and of comprehensiveness for the professionals responsible for collecting, processing, interpreting and/or using the indicators information.

Additionally, the measures focus predominantly on the donation phase, suggesting gaps in measuring efficiency in transplant and post-transplant stages. Despite representing the expected benefits of the whole ODT process, the follow-up of transplanted patients, including quality of life, adherence to medical treatment and morbidity rates, were not addressed in the indicators.

Complex issues that can impact the supply of organs, such as logistical aspects, underreporting of brain death by healthcare professionals, as well as the causes of family non-consent for organ donation, were also poorly addressed. Another issue is that few studies correlated the indicators results with institutional factors (internal to the unit of analysis, such as the transplant center size and patient mix) or contextual factors (external to the unit of analysis, as the cultural, social and economic aspects where the transplant center is located) that may impact the process measured and help to explain, at least in part, the numbers obtained.

This study contributed to organize and expand the knowledge on ODT performance indicators. This effort allowed the identification of aspects barely investigated within the subject, showed the diversity of existing indicators and measures, and clarified the need for new indicators to monitor and improve the ODT process.

Through a mathematical technique called DEA, the second article estimated the relative efficiency of Brazilian states in performing kidney transplantation services. The performance of each federal unit was compared to the remaining states in the sample, regarding the conversion of physical and human resources into health outcomes. More specifically, the technical efficiency scores represented the extent to which outputs, namely, the number of kidney transplants, could be maximized while maintaining constant the input levels, represented by the number of medical teams performing kidney transplant surgery; the number of organ procurement organizations; the number of ICU beds; and the number of effective donors at each state. The impact of scale on efficiency was also assessed, indicating whether the states' ODT programs were operating at optimal, oversized or undersized dimensions.

The results indicate that most states operate in a technically inefficient manner, resulting in a low mean efficiency score. This indicates significant room for improvement in the allocation of resources. Overall efficiency worsened during the analyzed period, and there was a significant disparity in performance between states, with higher scores in the South and Southeast—the most developed and wealthiest regions—than in the North and Northeast. Additionally, the scale efficiency results indicate thar most states operate in reduced dimensions. The striking differences in efficiency scores between Brazil's regions suggest asymmetries in resource management. This finding highlights the importance of benchmarking for allowing states with the worst performance to learn from best practice and successful innovations in other locations. In turn, the comparison of the results of this study with the prior related literature indicates a high and persistent level of

inefficiency in the Brazilian public transplant services and a lack of improved efficiency in recent years. This study provides insights into the relative efficiency of the public services of kidney donation and transplantation, based on benchmarking Brazilian states in recent years.

While the first and second article relied, respectively, on the literature systematic search and on a mathematical method to measure the performance of ODT services, the third one followed an exploratory and qualitative approach to address the topic. Semi-structure interviews were applied to examine the perceptions of state transplant coordinators, responsible for managing ODT services in the state-level, on factors positively or negatively impacting the services performance.

Among the factors identified is the use of indicators as a basic management tool. They help identifying inefficiencies, guide decision-making on the need for new initiatives or investments and ground the dialogue with actors such as hospitals managers, donation teams and government representatives. Other factors identified for its positive impact are the relationship built with hospitals and other transplant centers; the state political stability; the altruistic interpersonal profile and relational skills of coordinators; and the provision of media coverage and campaigns to raise public awareness on organ donation.

The article intends to contribute to the healthcare practice and literature by developing a conceptual framework that provides policy-makers, managers, practitioners and researchers an overview of the multiple factors affecting the performance of ODT services. Based on the identified factors, a list of good practices is proposed and provide a basis for future research.

The first supplementary study examined the attitude of medical and nursing personal of two Brazilian hospitals towards deceased organ donation, and the variables associated with a positive attitude. Although organ donation is well accepted among most healthcare professionals surveyed, the results indicate an opportunity for improvements in the awareness of physicians and nurses who had an indecisive or negative attitude. Additionally, a positive attitude seems to be related to socio-personal variables. The associations observed show the importance of encouraging discussions about organ donation in the family environment, for both healthcare professionals and general population. By providing proper training and motivation, thus clarifying doubts and concerns based on lack of information, professionals are empowered with technical and social capabilities that enhance the confidence to work with ODT activities. Is worth mentioning that there is robust evidence from the literature suggesting the importance of a positive attitude of healthcare professionals, such as physicians and nurses, towards organ donation. These

professionals are potential opinion leaders, able to inform, clarify, and stimulate the health system's users to discuss organ donation with family and friends.

Finally, the second supplementary article adopted a systematic literature review to map innovations within ODT activities. In general, innovations are measured from their effects on a group of individuals and are distributed in the various stages of the ODT process. The innovations in the field are analyzed mainly under a clinical spectrum, through the description of the innovation and its medical results. They include, for example, surgical techniques to improve organ procurement or transplant surgeries results, devices and equipment aimed to assist the organ extracorporeal preservation and the potential donor clinical maintenance.

In turn, few innovations focus on managerial aspects. Innovative efforts in this category included lean process applied to the patient's workflow, aiming to reduce patients' referral time until their inclusion in the transplant list, online course for medical education in transplantation, and hospital measures aimed to support organ donation, such as the hiring of professionals dedicated full-time to these activities. Another interesting issue emerging from the results was the predominance of incremental innovations, bringing new services, products, processes or ideas that are not totally new or unprecedented in the sector. Thus, within the financial and regulatory limitations for innovation research within ODT, the findings signal that there is room for radical innovations in this field. Other gaps identified refer to the innovations' assessment regarding their economic, social and ethical impact, as well as the determinants for the innovation successful generation, adoption and/or diffusion.

Altogether, the studies' results converge to indicate limited professionalization in the management of ODT services, with the need for managerial actions pervading several stages of the process. More specifically, as presented in table 2, the managerial implications of the research refer to:

Table 2. Managerial Implications

Performance of organ donation-transplantation services	**Need for diversified measurement methods.** In addition to pertinent indicators, many mathematical/statistical tools can be applied to assess the performance and its determinants.
	Knowledge gaps regarding quality domains. As the quality of life of transplanted patients and how satisfied the families of potential deceased donor are with the healthcare delivered.
	Revise measurements' validity and reliability issues. A quality valuation of applied measures should comprise its data reliability, content validity and relevance, resource consumption, and comprehension by those processing or interpreting the information.
	Services' operation scale in Brazilian states. It considers economies of scale for sharing costs and of scarce resources, and by increasing the volume and expertise of healthcare units and professionals providing ODT services. The optimal size needs to consider the population access.
	Improve allocation of available resources. Aims to reduce wastes and reworks in the coordination of human, material, physical and financial assets. It should consider benchmarking and identifying both successful and ineffective practices to be adapted or avoided.
	Revise remuneration, training and motivation issues. Of professionals directly or indirectly involved with ODT services, mainly regarding the provision of managerial capabilities. It underlies the attitude and competence to perform time-sensitive and technically-complex activities.
	Room for innovation research. Applied to scarcely explored areas, mainly regarding managerial tools aimed to improve organizational and healthcare delivery processes.

Regarding the overall theoretical contributions, given the paucity of studies systematically examining the performance in this field, the present thesis extends the current knowledge on the performance measurement and on the potential improvement areas of ODT services. The results also throw light to knowledge gaps and methodological shortcomings within ODT literature, intending to stimulate new academic studies and further debates on the interface of ODT services and performance management fields. Regarding the overall managerial contributions, the results of each article developed are summarized in a set of managerial recommendations, aiming to translate in accessible language an agenda that can be put in practice for the performance management of ODT services. By providing a better understanding of performance improvement areas and potential means to address them, this doctoral thesis intends to be useful for researchers, managers, practitioners and policy-makers on ODT field, drawing closer the medicine and healthcare management domains.

7.2.Limitations and future research

The limitations of each stage of the research, as well as the indication for future researches resulting from their findings, are addressed in their respective articles. Regarding the doctoral thesis as a whole, the choice for distinct methods to directly or indirectly assess the performance and its influence factors on ODT services has limited the replicability of findings across studies. Also due to the complexity of the subject and the diversity of literature, the results should be interpreted with caution.

Future research can update and expand the time-frame of the primary and secondary data collected and analyzed in this research. Additionally, the choice of a common unit of analysis across the different research methods applied, such as specific hospitals and its professionals, while performing the same type of ODT activities in the same time period, would allow closely linked analysis throughout complementary articles.

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APPENDICES

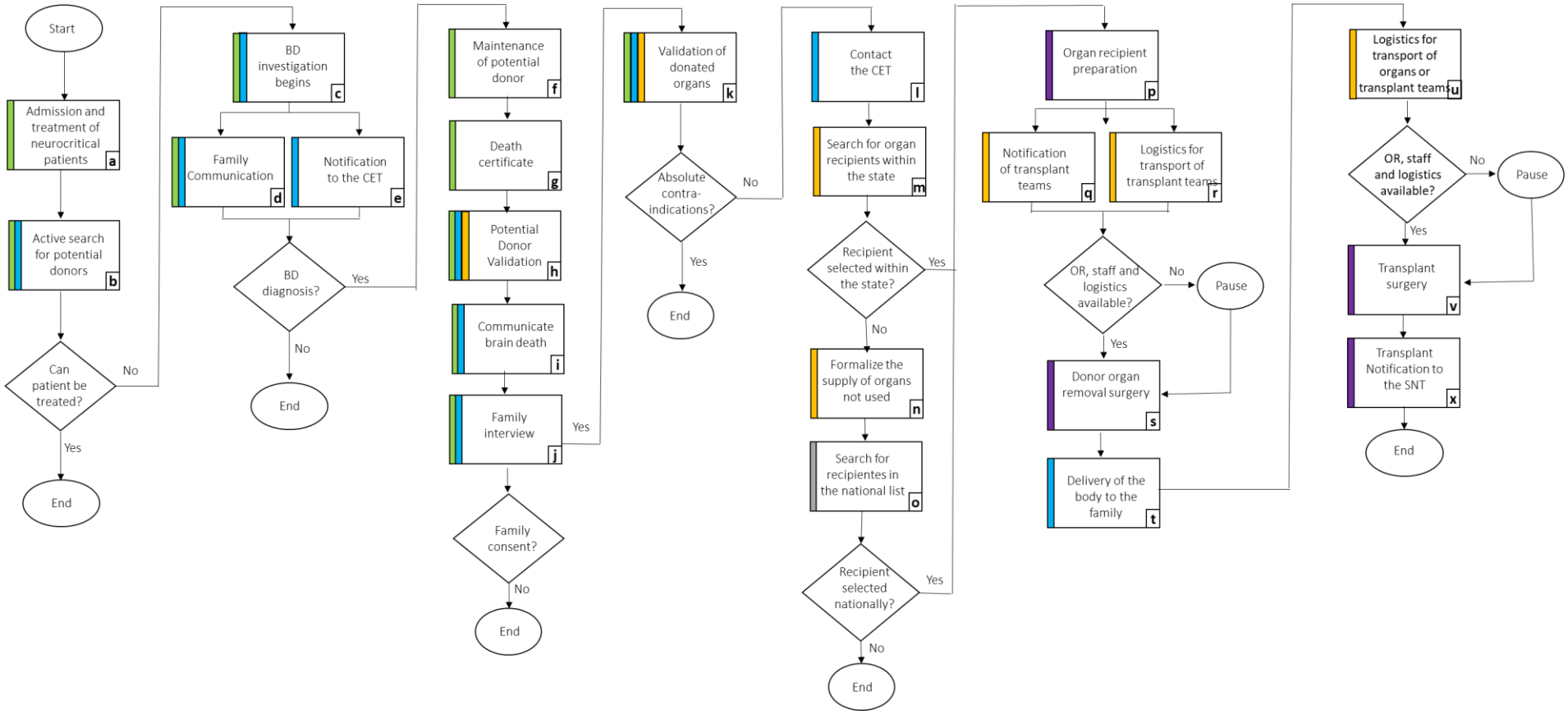
Appendix 1. Landmark legislation for organ donation and transplantation in Brazil

80s	• The discovery and use of a new immunosuppressive drug led to encouraging results and to the reactivation of transplant programs in Brazil, such as heart, pancreas and lung.
1987	• Until then, donors search and allocation were performed by the transplant centers, without any coordination dedicated specifically to these activities and no participation of the Ministry of Health. In this year, some states, as Rio de Janeiro, São Paulo and Rio Grande do Sul, took on these tasks through government agencies and foundations.
1996	• With the exception of kidney transplantation, the absolute number of solid organ transplants only became expressive in Brazil from this year.
1997	• With the increase in the number of successful transplants, it became imperative to implement unified coordination and advance the regulation of this activity. Thus, the Ministry of Health created, by Decree Law No. 2.268, the National Transplant System and the State Transplant Centers, also establishing the Technical Registry – national single list for the distribution of organs and tissues. • There is a waiting list for each organ at each state, following criteria such as the registration order and the donor compatibility. If an organ cannot be transplanted in the state where it was notified, it may be made available to the waiting list of other states. • Law No. 9,434 was published, which conceptualized and established brain death as a mandatory criterion for organ removal from the deceased potential donor. Life-giving is now allowed, in cases of doubled organs, tissues or body parts whose withdrawal does not compromise the organism's functioning, vital skills and mental health, does not cause unacceptable mutilation or deformation, and represents a therapeutic need indispensable to the receiver. The law also altered the previous consent system, establishing the presumed consent, in which non-manifestation of contrary will presupposes authorization for the donation of organs and tissues by the potential deceased donor. • Several procedures related to organ transplantation started to be funded by SUS, from donor search to post-transplant follow-up.
1999	• All funding for donation & transplantation was included in a new fund (FAEC), whereby the transfers from federal government to states and municipalities would be the responsibility of the Ministry of Health and would cover all stages of donation & transplantation process. Previously, financial problems compromised the results in this

	field. They included non-reimbursement to hospitals for its donor search activities, undermost payment for outpatient follow-up after transplant surgery and interruptions in the supply of immunosuppressive medications.
2000	• The National Registry of Organ and Tissue Donors was created to register those across the country who wanted to become donors after death. The registry replaced the previous system of mandatory expression of will, by which citizens' ID and driver's license had to present the 'donor' or 'non-donor' information.
2001	• Organ donation through informed consent takes effect through Law No. 10.211. • There was an adjustment in the amounts paid by SUS for organ donation and transplantation procedures. The remuneration for organ procurement procedure was tripled, and, as a Teaching and Research Development Incentive, University and Teaching Hospitals started received an additional funding of 25%, 50% or 75%. The aim was to encourage these hospitals to expand its transplant activities.

Source: Based on SNT, 2009; MS, 2014; MOURA et al., 2009 and HERINGER, 2010.

Appendix 2. Process mapping of organ donation-transplantation services in Brazil



Source: Developed by authors

**The process-mapping chart was developed considering government documents and ODT academic literature including laws and regulations, official documents and reports from the Ministry of Health, the National Transplant System and the Brazilian Organ Transplant Association. In addition, one intensivist physician and a nurse who work at the forefront of ODT services were consulted, in an iterative process.*

Appendix 2. Process mapping of organ donation-transplantation services in Brazil — Activities Description [continued]

a. **Admission and treatment of neurocritical patients:** Patients' arrive at Urgency/Emergency hospitals and ICUS. They are treated by the hospitals clinical team.
b. **Active search for potential donors:** The timely identification of potential donors is carried out daily by hospitals' medical and donation teams. Possible donors become potential donors only after Brain Death confirmation. The most frequent causes of Brain Death are traumatic brain injuries and strokes.
c. **Brain Death diagnosis:** The opening of a Brain Death protocol leads to clinical and complementary exams to confirm the diagnosis, following rules established by the Federal Council of Medicine. They are performed by the hospital medical team, including a neurologist.
d. **Family communication:** Performed by the doctor responsible for the patient, often with the involvement of the hospital donation team. It aims to communicate the Brain Death eminence and to clarify any doubts.
e. **Potential donor notification:** The hospital donation team notifies the respective State Transplant Center on the existence of a potential donor.
f. **Maintenance of the potential donor:** The monitoring and clinical maintenance of the potential donor seeks the viability and quality of the organs and tissues that can be donated. Maintenance should be started as soon as the Brain Death investigation begins. And it lasts until the organ is removed for transplantation.
g. **Death certificate:** The hospital provides the potential donor death certificate.
h. **Potential donor validation:** The validation of potential donors involves exams to assess medical contraindications to the donation. It precedes the family interview and lasts until the removal of organs, since new circumstances that make the donation impossible may arise or be discovered. Non-absolute contraindications are discussed by the state transplant center and the responsible medical team.
i. **Family communication:** Performed by the doctor responsible for the patient, often with the support of the hospital donation team. It conveys the Brain Death.

j. **Family interview:** Besides clarifying any doubts and offer support to the mourning family, this stage explains the organ donation possibility, which is a family right secured in law, at the Unified Health System expenses. It is performed by a professional referred by the state transplant center, or member of the hospital's donation team, together with the doctor responsible for the patient. The process sequence requires the family consent to the donation of organs of the deceased relative.

k. **Clinical validation of donated organs:** After family consent, the clinical validity of donated organs is performed, with tests such as serology for Chagas, Syphilis, Hepatitis, HIV and Toxoplasmosis. They aim to identify possible absolute medical contraindications that make the donation unfeasible or put the recipient's health at risk. The validation lasts until the organ's removal, since new contraindications or complications may arise. Non-absolute contraindications are discussed by the state transplant center and the responsible medical team.

l. **Contact with the respective State Transplant Center:** It aims to inform which donated organs and tissues will be transplanted, their clinical and laboratory conditions, and the estimated date for carrying out the procurement procedure.

m. **Search for transplant recipients within the State's transplant list:** The State Transplant Center requests, in its computerized information system, the automated ranking of recipients, following the results of immunological compatibility tests between donor and recipient and law-criteria.

n. **Formal national offer of non-utilized organs:** When a recipient is not identified in the state where the organ was donated, the state transplant center formalizes the organ's offer at the national level.

o. **Search for transplant recipients within the national transplant list:** The National Transplant Center performs the search for recipients on the national transplant list.

p. **Transplant recipient preparation:** The hospitalization of the selected recipient and the admission exams prior to transplant surgery are performed, according to the organ to be implanted.

q. **Medical staff notification on the procurement and transplantation surgeries:** The notification of transplant teams and the scheduling of medical staff and operating rooms for organs removal and transplantation are performed.

r. **Medical teams' logistics:** The state transplant center organizes the logistics for transporting transplant teams to the hospital where the organ removal will be performed. The procurement and transplant teams may be or may not be the same.

s. **Procurement surgery:** Surgery to remove donated organs. In sequence, in the case of kidneys and pancreas, the state transplant center also organizes the cross-test of serological compatibility between the organs and their respective receptors.

t. **Delivery of the body to the family:** Delivery of the donor's body, duly recomposed, to the family or to the Legal Medical Institute.

u. **Transplant Surgery**: Transplantation of the donated organ in the previously selected recipient. It is performed by the scheduled transplant team.

v. **Transplant notification**: The transplant team notifies the respective state transplant center and the National Transplantation System's regarding the transplant performed, so that the donor and recipient rankings on the transplant list are updated.

w. **Transport logistics of medical teams and organs:** After the scheduling of medical teams and operating rooms, the state transplant center organizes the logistics for transporting medical transplant teams and donated organs to the transplant hospital.