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Analysis of the Cost of Maintaining Effective Donors and Nondonors of Organs and Tissues in Intensive Care Units

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ABSTRACT

Background. The costs of potential donors are not fully known in Brazil, as in other countries, especially during the period that patients remain in intensive care units.

Objectives. This study aims to evaluate the cost of maintaining effective donors and nondonors of organs and tissues for transplants in intensive care units using the microcosting technique.

Methods. An economic cost analysis using 3 retrospective cohorts constructed from secondary data collected over a 1-year period from medical records of deceased patients who had a protocol opened for brain death investigation. Cost measurement followed the 8 steps of the Time-Driven Activity-Based Costing method.

Results. The average cost of the effective donor was US$3220.04. The cost of the nondonor due to family refusal was US$1346.48. The cost of the nondonor due to medical refusal was US $1144.90. Organs and tissues donated but not collected totaled US$16,656.92.

Conclusions. A review of work processes and adopting strategies to mitigate the failure to complete donations in all outcomes are necessary, since the sum of the amounts spent on medical refusal, family refusal, and problems preventing collection amounted to a total of US$104,121.66 in 1 year.

A transplant occurs through a donor, who can be alive or deceased, to a sick individual called a recipient [1]. Organs specifically in relation to the deceased donor can be obtained from a donor in a state of brain death (BD) or after circulatory death [2]. Organs such as the heart, lungs, kidneys, liver, pancreas and intestine, and/or tissues such as corneas, sclera, skin, bones, cartilage, tendons, menisci, muscle fascia, heart valves, and blood vessels can be harvested in the case of deceased donors in BD [2].

The logistics for harvesting to occur must be organized according to the maximum ischemia time supported by each organ and the transplant procedure to be performed; the maximum times for these in Brazil are 4 hours for a heart, 4 to 6 hours for a lung, 12 hours for a liver and pancreas, and up to 48 hours for the kidneys [3].

All financing for this process, from maintenance of the potential donor and eligible donor fit to donate organs, to the removal, implantation of organs and tissues, and post-transplant

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monitoring, is done by the Brazilian Unified Health System (*Sistema Único de Saúde - SUS*) [4].

Because transplantation is often the last therapeutic resource, as well as complex and expensive, it is disastrous when it is not performed either due to family refusal, medical refusal, or even discarding organs and tissues that were collected and not transplanted, as this substantially contributes to the growing waiting list in the Single Technical Registry (*Cadastro Técnico Único - CTU*) [5].

The costs of potential donors are not fully known in Brazil (as in other countries), especially during the period that patients remain in intensive care units (ICU) waiting for exams, procedures, and family authorization to continue the process. The few existing studies mostly portray the total transplantation cost with aggregated cost analyses, and so they do not indicate the individual cost to the patient [6].

Considering the existence of costs in managing effective donor and nondonor organs in the ICU and the lack of studies that portray the cost of these outcomes through a microcosting technique [7], this study used the Time-Driven Activity-Based Costing (TDABC) method based on activities and time [8].

Thus, the objective of this study was to evaluate the cost of maintaining effective donor and nondonor organs and tissues for transplants in the ICU through the microcosting technique.

METHOD

This is a cost study using 3 retrospective cohorts based on secondary data from the medical records of patients who died and had a protocol opened for investigation of BD for organ and tissue harvesting in a referral service for transplants in the state of Mato Grosso do Sul, in the Central-West region of Brazil.

The study was conducted in accordance with the regulatory guidelines for research involving human beings established by Resolution No. 466 of December 12, 2012, of the National Health Council of the Brazilian Ministry of Health. It was previously approved by the Research Ethics Committee of the Federal University of Mato Grosso do Sul (UFMS) under substantiated opinion No. 5,381,784 and CAAE No. 50810121.5.0000.0021. The medical records of patients in which the responsible family member signed a written informed consent form were included. The study did not include minors.

Data were collected from medical records of the Medical and Statistical Archive Service (*Serviço de Arquivo Médico e Estatístico - SAME*) and related sectors from October 2022 to August 2023. The population for cost analysis of this study was composed of a census of all patients treated from January 1 to December 31, 2019, identified as effective donors or nondonors of organs and tissues admitted to the ICU. The time frame for cost analysis (year 2019) is justified because it was the year before the COVID-19 pandemic to exclude biases which could affect costs due to the impact generated. The authors did not have access to information that could identify individual participants during or after data collection.

An effective donor was monitored until their transfer time to the surgical center. Nondonors were monitored until death. The 8 steps of the TDABC method [9] were followed to measure costs per patient. The study included the 21 elements classified as mandatory in executing the method [10].

The population of this study was composed of 32 effective donors and 69 nondonors, whose noneffectiveness was due to family refusal in 42 situations and due to medical refusal in 27 situations.

Process Map and Identification of Resources in Each Activity

After visiting and monitoring the routine of the Organ Procurement Organization (*Organização de Procura de Órgãos - OPO*) sector at the hospital and analyzing the medical records, the start and end of the care provided to the patients in question were mapped within a chain of care. The identified activities were listed as direct costs (exams, medications, medicinal gases, nutritional therapy, medical-hospital supplies/materials, and health care team) and indirect costs (water, electricity, telephone, internet, equipment depreciation, equipment maintenance, laundry team, administrative, and cleaning services). The resources used by the patients were then classified as structural (water, electricity, telephone, laundry, depreciation, and equipment maintenance costs) and personnel costs (healthcare team, cleaning and administrative staff). Medication, diet therapy, medicinal gases, laboratory and imaging tests and consumables were included in the next step.

Total Costs for Each Resource Group and Department, Capacity of Each Resource, and Capacity Cost Rate (Cost/Hour)

The cost items for each activity were estimated over a 12-month period, from which the average cost of each resource was determined. Then, the number of consumption hours of the analyzed resource was established.

The expenses for water, electricity, telephone, internet, equipment maintenance, medical gases, diet therapy, and imaging exams were obtained through current contracts, agreements, and financial statements available on the transparency portal of the analyzed hospital [11].

Considering that water, electricity, telephone, and internet are used uninterruptedly during hospitalization, the usage time was established as 24 hours. The cost of each expense was obtained through the average cost over a 12-month period, divided by the number of cost centers in the institution studied (51 sectors), and then by the number of beds in the sectors studied. This was how the cost/hour was obtained.

Personnel costs (nursing, doctors, social workers, physiotherapists, dentists, administrative staff, and cleaning staff) were obtained by requesting the monthly income of each category from the institution’s human resources department. In addition, considering that there are legal and social charges defined by current labor legislation, such as paid weekly rest, vacations, 13th salary (year-end bonus), and severance pay (among others), an increase of 19.11% (practiced at the institution) was adopted to the value of the hourly cost of work.

Practical capacity was obtained through the monthly workload of each class of workers, obtained from the human resources department. Then the cost/hour (capacity cost rate) was obtained from this using the salary base and the time worked per month.

In turn, the costs of medications and consumables, laundry, and equipment depreciation were incorporated into the cost information. A survey regarding medications, laboratory and imaging tests, and consumables was carried out after a retrospective analysis of the patients' medical records in the year analyzed.

Next, the medical and nursing prescriptions were consulted with a survey of all the tests, medications, and supplies used by each of the patients to calculate the cost of medications, diet therapy, medicinal gases, and consumables. Then, calculations were made by multiplying the dose used or quantity of consumables, or the number of times the tests were performed, by the current value of the product obtained from the institution's warehouse and online transparency portal.

The value for the laboratory service, which is an outsourced service, was directly obtained from the sector. The value spent on imaging tests and medical gases was obtained from contracts available on the hospital's online transparency portal.

Next, 2 calculations were performed to calculate the depreciation of permanent equipment and materials, one on the depreciation value and another on the cost of using the procedure, considering each piece of equipment obtained from information provided by the Medical, Nursing, and Physiotherapy managers in the inpatient sectors.

The depreciation value (DV) was obtained by multiplying the market value of the equipment (obtained from the institution's purchase contracts available on the transparency portal) by the depreciation rate, as determined by current Brazilian tax legislation, established by Normative Instruction of the Brazilian Federal Revenue Service RFB No. 1,700, Annex 3, dated March 14, 2017 [12].

The cost per procedure (CP) was calculated using the formula described below for each of the equipment used: bed, mechanical ventilator, multiparameter monitor, IV stand, bedside table, and electrocardiogram device (among others). Equipment that requires uninterrupted use (e.g., monitors, ventilators, beds, IV stands, or bedside tables) was considered to have a daily usage time of 24 hours.

$$CP = \langle (VD \big| 365) \big| \text{Usage time in 24 hours} \times \text{Usage hours by the potential donor} \rangle$$

Note: CP, Cost per procedure; DV, Depreciation value.

Regarding equipment for occasional use (cupometer, electrocardiograph, and auxiliary table), the healthcare team that provides care to the patient was asked about the usage time of the respective equipment in 24 hours, which determined the hourly cost of the procedure.

Then, it was verified which services are performed in the hospital itself and which are outsourced to assess the maintenance cost of biomedical equipment. The total costs of this maintenance were then collected through the hospital's transparency portal, and the average cost for each ICU bed was calculated by means of apportion.

For laundry, a printed copy was requested of the average quantity of hospital linen received to be processed by the laundry from the sectors that serve the potential donor in 24 hours, and the estimated cost per kilo of clothing. The value per kilo of clothing per sector was then calculated, and from this, the average cost per patient was obtained.

Time estimation for each resource and total cost. The actual time spent using each resource by the potential donor for structural activities and human resources was established. The time the patient spent in the ICU from the time BD was suspected was used for structural activities such as water, electricity, telephone, and internet.

A form sent to professionals involved in the care of the potential donor was used to obtain the average time in 24 hours that each professional spent on the patient in question to determine the time spent on human resources in the health area. Specifically in relation to Nursing, the institution uses the Therapeutic Intervention Scoring System (TISS-28) tool from which the dedicated hours were obtained. The calculation of the time spent by administrative and cleaning staff was made by considering the time the patient spent in the ICU from the time BD was suspected.

The total cost was obtained using time equations for each activity [9], as shown below, in which: C corresponds to the total cost; β corresponds to the time used by the potential donor for each activity (structural costs, health team and administrative costs); CCR corresponds to the capacity cost rate of each activity (cost/hour); and Y corresponds to other direct/indirect costs (medication, consumables, equipment depreciation, equipment maintenance and laundry), associated with the hospitalization process.

$$\begin{aligned} C &= \sum \beta \text{i x CCRi} + \text{y} \\ &= \beta 1 \text{ x CCR1} + \beta 2 \text{ x CCR2} + \cdots + \beta \text{n x CCRn} + \text{y} \end{aligned}$$

The monetary values of costs were expressed in United States dollars (USD), according to the exchange rate of the Central Bank of Brazil. Although the medical records evaluated were for the year 2019, the values used for structural costs, personnel expenses, medicines, and consumables cost data were from the year 2025.

Data Analysis and Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS for Windows, version 25.0) software package.

The χ^2 test, Students *t* test and analysis of variance were used to verify the association between variables. When the analysis of variance was significant, the Bonferroni test was applied to determine where the significant difference was occurring. The Kolmogorov−Smirnov test was applied to verify the data normality. A significance level of 5% (0.05) was adopted in all tests applied.

RESULTS

The epidemiological characterization of effective donors is described in Table 1. The majority of donors were female

Table 1. Characterization of Effective Organ and Tissue Donors. Campo Grande/ MS, Brazil, 2025 (n = 32)

Characteristics	n (%)	
Sex	Female	17 (53.12)
	Male	15 (46.88)
Age range (y)	Up to 30	03 (09.37)
	31-39	04 (12.50)
	40-49	07 (21.88)
	50-59	08 (25.00)
	60-70	10 (31.25)
	Over 70	00 (00.00)
Age range	Up to 54 years	18 (56.25)
	55 years or older	14 (43.75)
Ethnicity	Yellow	01 (03.12)
	White	08 (25.00)
	Indigenous	00 (00.00)
	Black	01 (03.12)
	Mixed race	22 (68.76)
Education	Illiterate	01 (03.12)
	Elementary education	21 (65.63)
	Secondary education	09 (28.13)
	Higher education	01 (03.12)
Civil status	Married	10 (31.25)
	No partner	22 (68.75)
Origin/location	State capital	20 (62.50)
	Inland	12 (37.50)

Table 2. Characterization of Nonorgan and Tissue Donors. Campo Grande/MS, Brazil, 2025 (n = 69)

Characteristics	n (%)	
Sex	Female	32 (46.37)
	Male	37 (53.63)
Age range (y)	Up to 30	06 (08.69)
	31-39	08 (11.60)
	40-49	07 (10.15)
	50-59	21 (30.44)
	60-70	16 (23.18)
	Over 70	11 (15.94)
Age range	Up to 54 years	27 (39.14)
	55 years or older	42 (60.86)
Ethnicity	Yellow	01 (01.45)
	White	14 (20.30)
	Indigenous	04 (05.80)
	Black	01 (01.45)
	Mixed race	49 (71.00)
Education	Illiterate	07 (10.15)
	Elementary education	47 (68.12)
	Secondary education	12 (17.39)
	Higher education	03 (04.34)
Civil status	Married	32 (46.38)
	No partner	37 (53.62)
Origin/location	State capital	37 (53.62)
	Inland	32 (46.38)

(53.12%), aged 60 to 70 years (31.25%), of mixed race (68.76%), without a partner (68.75%), with elementary education (65.63%), and from the state capital (62.50%) of Mato Grosso do Sul. When a cut-off point of 55 years was established, the majority of donors were up to 54 years old (56.25%).

The epidemiological characterization of nonorgan and tissue donor patients is described in Table 2. Most patients were male (53.63%), aged 50 to 59 years, of mixed race (71%), with elementary education (68.12%), without a partner (53.63%), and from the state capital (53.62%). There were no indigenous organ donor patients. When a cut-off point of 55 years was established, the majority were 55 years or older (60.86%).

Regarding hospitalization causes, hemorrhagic vascular events were predominant among nondonors and donors. Traumatic brain injury was the second most common reason among donors and nondonors due to family refusal. The second most common cause among nondonors due to medical refusal was ischemic vascular events.

Specifically in relation to effective donors, a total of 121 organs and 64 corneas (tissues) were donated, with an average donation of 3.78 organs and 2 corneas per patient. However, 62 organs (51.23%) and 62 corneas (96.88%) were actually collected, which amounts to an organ collection rate of 51% and a cornea collection rate of 96.8%. It is important to highlight that only 33% of the donated livers and 10% of the pancreases were actually collected. Regarding hearts and lungs, 8 hearts and 18 lungs were donated, however none of them were collected.

The main reason for organs being donated but not collected (27%) was organ inspection during surgery by the collection team and finding that it was unsuitable for transplants due to some previous problem not identified during the potential donor or eligible donor phase.

Another reason was the clinical condition (gravity of the donor) that led to rejection by local or national vacancy centers (13.55%), followed by the national ranking expiring due to the lack of a suitable or compatible recipient (13.55%). Logistical problems such as lack of aircraft (10.16%), lack of a team for collection (10.16%), and aircraft failure (1.69%) were responsible for the nonrecovery of 14 organs.

The main causes of family refusal to donate organs and tissues were the donor's refusal while alive (47.61%), followed by the family's desire to keep the body intact (26.19%) and ignorance of the family member's wishes (11.90%).

The length of stay in the ICU varied according to the outcomes of donor, nondonor due to family refusal, and nondonor due to medical refusal (Table 3). Patients who did not donate organs due to medical refusal had a longer average time between hospitalization and suspicion of BD when compared to the other 2 outcomes. It was found that this longer time was statistically significant ($P = .015$).

The time between suspicion and confirmation of BD, as well as the total length of stay in the ICU until the outcome of donor or nondonor, was longer in organ and tissue donors.

The composition of costs according to the effective donor or nondonor outcomes is described in Table 4. The average total cost of the effective donor was US$3220.04. The cost of the nondonor due to family refusal was US$1346.48. The cost of the nondonor due to medical refusal was US $1144.90.

Table 3. Length of Stay in the Intensive Care Unit of Donors (n = 32), Nondonors Due to Family Refusal (n = 42), and Nondonors Due to Medical Refusal (n = 27) of Organs and Tissues for transplantation. Campo Grande/MS, Brazil, 2025 (n = 101).

Time (h/min)	Outcome	Minimum	Maximum	Mean	SD	*P*
Time between hospitalization and suspected BD	Donor	2.50	264.00	77.68^{AB}	83.03	.015*
	Family refusal	1.00	312.00	47.18^{B}	65.77	
	Medical refusal	2.00	768.00	124.96^{A}	165.35	
Time between suspected and confirmed BD	Donor	2.15	120.00	15.20	20.15	.415
	Family refusal	1.50	29.50	11.15	7.79	
	Medical refusal	2.00	24.50	12.55	6.08	
Time between confirmed BD and CRA or SC	Donor	3.28	53.32	24.38^{A}	9.88	<.001*
	Family refusal	1.29	26.03	7.98^{B}	6.09	
	Medical refusal	0.00	14.24	3.85^{B}	3.83	
Time in ICU from suspected BD to outcome	Donor	8.47	144.33	39.66^{A}	21.91	<.001*
	Family refusal	3.51	46.16	19.13^{B}	9.03	
	Medical refusal	2.00	28.66	16.21^{B}	6.57	

BD, brain death; CRA, cardiorespiratory arrest; ICU, intensive care unit; SC, surgical center; SD, Standard Deviation.
[A,B]Means followed by the same letter do not differ statistically from each other. The Bonferroni test was applied at a significance level of 5%. *Statistically significant associations.
* Statistically significant associations.

Investment in the health team was predominant regarding direct costs in all outcomes, followed by exams, medications, and hospital supplies. There was also a predominance of expenditure on human resources in indirect costs. The other indirect costs spent on water, electricity, telephone, depreciation, and maintenance of equipment represented a lower amount spent in all outcomes.

Statistically significant correlations were found between being an effective donor and higher costs for health professionals, exams, nutrition, medical gases, hospital supplies,

Table 4. Cost Composition of Donors (n = 32), Nondonors Due to Family Refusal (n = 42), and Nondonors Due to Medical Refusal (n = 27) of Organs and Tissues for Transplantation. Campo Grande/MS, Brazil, 2025 (n = 101)

Costs (in USD)	Outcome	Minimum	Maximum	Mean	SD	*P*
Direct costs - Exams	Donor	272.47	656.78	445.27^{A}	626.72	<.001*
	Family refusal	128.76	279.57	184.18^{B}	209.32	
	Medical refusal	37.53	186.29	133.17^{C}	150.54	
Direct costs - Medications	Donor	20.79	276.93	77.98	271.96	.106
	Family refusal	2.45	228.43	42.44	225.89	
	Medical refusal	7.65	503.44	63.48	691.47	
Direct costs – Medical gases	Donor	14.84	252.91	69.51^{A}	221.93	<.001*
	Family refusal	6.15	80.88	33.52^{B}	91.44	
	Medical refusal	3.50	50.22	28.41^{B}	66.58	
Direct costs – Nutritional support	Donor	0.00	18.68	7.43^{A}	31.30	.001*
	Family refusal	0.00	23.35	6.67^{A}	28.06	
	Medical refusal	0.00	9.34	2.94^{B}	20.02	
Direct costs – Hospital supplies	Donor	67.62	151.31	85.01^{A}	87.46	<.001*
	Family refusal	31.01	99.76	58.76^{B}	91.80	
	Medical refusal	11.30	76.21	48.62^{C}	101.17	
Direct costs – Health team	Donor	422.74	3687.46	1967.67	471.47	<0.001*
	Family refusal	176.47	2294.14	951.99^{B}	2590.93	
	Medical refusal	101.49	1425.23	807.29^{B}	1886.44	
Indirect costs - Personnel	Donor	36.06	847.91	347.53^{A}	1436.40	<.001*
	Family refusal	28.39	117.32	53.64^{B}	100.23	
	Medical refusal	26.06	67.29	48.04^{B}	58.76	
Other indirect costs	Donor	6.75	596.16	219.59^{A}	1013.97	<.001*
	Family refusal	2.79	36.81	15.25^{B}	41.61	
	Medical refusal	1.59	22.85	12.93^{B}	30.30	
Total cost	Donor	841.31	6488.16	3220.04	4161.21	<.001*
	Family refusal	400.40	2964.38	1346.48^{B}	2991.65	
	Medical refusal	227.90	1810.86	1144.90^{B}	2099.71	

SD, Standard Deviation.
[A,B]Means followed by the same letter do not differ statistically from each other. The Bonferroni test was applied at a significance level of 5%. *Statistically significant associations.

indirect costs with personnel, and other indirect costs (Table 4).

Regarding the composition of direct and indirect costs in the total value of each outcome, direct costs in the actual donor outcome accounted for 82.38% of the amount, while indirect costs accounted for 17.62%. Direct costs in family refusal accounted for 94.36% of the expenses, while indirect costs accounted for 5.64%. Direct costs in the case of medical refusal accounted for 94.67% of the total amount, while indirect costs accounted for 5.33%.

Considering that the average cost of each actual donor was US$3220.04 and that there were 32 donors in 1 year, the total annual cost was US$103,214.33, with the donation of 121 organs and 64 tissues (corneas). This amounts to an average value of US$557.91 for each organ or tissue collected.

However, only 62 organs and 62 corneas were actually collected. Therefore, the average value of each organ and tissue collected corresponds to US$830.97, meaning US$273.06 more, which in the time horizon of 1 year represents a lost opportunity cost of US$16,656.92.

When considering the loss due to lost opportunities to collect organs and tissues, the average cost of each impediment in the year evaluated was established. Organs unsuitable for transplantation after evaluation by the collection team cost US$4369.11. Together, logistical problems such as a lack of collection team, a lack of aircraft, and aircraft failure cost the public coffers US $3,821.09.

A correlation was performed between the characterization of donors and nondonors to verify possible associations and respective odds ratios. No statistical associations were found between organ and tissue donation or nondonation with the sociodemographic characterization variables of patients.

DISCUSSION

This study assessed the profile of effective donors and nondonors due to family refusal and medical refusal and estimated the composition of the direct, indirect, and total costs of this process using the TDABC microcosting economic analysis technique.

When the average age was established as 55 years, most effective donors were 54 years old or younger, while nondonors were 55 years old or older, which highlights age as an important factor in the organ procurement process. The age limits for deceased donors in Brazil are: 60 years for kidneys and livers; 18 to 45 years for kidneys-pancreas; 7 days to 50 years for pancreas; up to 50 years for hearts; and up to 65 years for lungs [2].

There are currently 1253 services and 1664 teams qualified for transplants in Brazil [13]. In the state of Mato Grosso do Sul, where this study was conducted, there are 2 specialized teams for kidney collection; 16 teams for corneas, and one for musculoskeletal tissue, duly authorized by the National Transplant System of the Ministry of Health [14]. Up to September 2023, a total of 203 transplants had been performed in Mato Grosso do Sul according to the Ministry of Health, namely: 25 kidneys and 178 corneas [15], which in line with the findings of this study demonstrates greater ease in collecting and transplanting organs and tissues when there is a local team prepared and qualified for this purpose, as Brazil faces serious logistical problems for organ transportation [16].

When there is no local team for organ collection, it is necessary to bring a specialized team from another state in the country. This transportation of the team and the collected organs takes place due to a cooperation agreement involving the Ministry of Health, Commercial Aviation Companies, and the Brazilian Air Force (*Força Aérea Brasileira - FAB*). As far as airlines are concerned, transportation is included in existing routes and is provided free of charge [17].

The *FAB* is activated in the most critical situations, when it is not possible to use a commercial route due to the organ ischemia time. However, the FAB's refusal to collect organs in 2015 was 77.5%, mainly due to a lack of aircraft and a lack of a dedicated budget for this purpose [18]. Logistics is therefore a challenge, when national data show that around 18% of donated hearts are not effectively collected due to the organ's expiration [16].

It is important to highlight the costs of US$3821.09 in maintaining individuals as potential donors in the ICU, and nonfulfillment of the patient's and family's wishes at the end of the process due to a logistical problem of a lack of staff and aircraft, which results in individuals waiting for organs and tissues for longer on waiting lists.

Also noteworthy in this scenario of finite aircraft and teams is the case in which the team is transported to the organ donor, but the collection does not take place due to some impending problem in the organs, which makes transplantation impossible. This occurred in 16 episodes and represented a cost of US $4369.11. Perhaps more accurate examinations of organs such as the liver, pancreas, lungs, kidneys, and heart could mitigate this event and reduce the cost of lost opportunities.

Regarding costs, the effective donor costs the public coffers an average of US$3220.04. Nondonor due to family refusal had a cost of US$1346.48, while nondonor due to medical refusal spent an average of US$1144.90. The direct cost with the health team was predominant in all outcomes, followed by exams, medications, and hospital supplies. There was also a predominance of expenses with human resources in indirect costs.

The higher cost of effective donors compared to nondonors is justified by the longer stay in the ICU and the consequent use of human and material resources for donor management, which includes clinical maintenance with high-quality intensive care to optimize the function of donated organs and prevent graft failure in recipients until the transfer moment to the surgical center and removal of organs and tissues by qualified teams [19].

A study conducted in Australia involving economic evaluation by microcosting with 42 effective donors found a cost of US$7520.00. The Australian costs are higher than those found in this study, which can be justified by the difference in allocation of resources and technologies between developed and underdeveloped countries [20]. The composition of costs was similar, with the majority being allocated to health professionals, followed by imaging and routine exams, and finally medications.

The process of obtaining organs and tissues is considered costly to health systems [21]. These costs are justified because multiple actions need to be performed quickly in a coordinated and structured manner in the ICU from the moment BD is suspected and a potential donor is identified in order to keep the individual fit for donation [19]. These actions require qualified labor, use of technology [22], invasive monitoring, pharmacological support, and frequent laboratory tests to assess the effectiveness of the therapy [23].

All these investments and the failure to donate due to family and medical refusal are worth mentioning. When considering the average cost of US$1346.48 in nondonors due to family refusal and a population of 42 patients over the course of 1 year, an annual cost of US$56,552.29 to the public coffers is obtained for patients who did not become effective donors. In relation to nondonors due to medical refusal, an annual cost of US$30,912.44 was generated for the public treasury. Together, they amounted to US$87,464.74.

The main reason for family refusal to donate organs and tissues in this study was the donor's refusal while alive, followed by the family's desire to keep the body intact. Studies have attributed family refusal as the main problem in Brazil for preventing organ and tissue harvesting [24−26].

Organs are no longer donated in Brazil when the national ranking is depleted, and no suitable recipients are found. Countries in Europe share donated organs and tissues through Eurotransplant, the European Union, and Scandiatransplant when there are no compatible recipients locally. This is done through a single waiting list in order to reduce waiting times [27].

It is important to note that in Brazil, unlike in other countries, the organ procurement and transplantation process does not depend on the patient's financial means or private health insurance, as it is a system fully funded by the Brazilian government through the Unified Health System [4].

This study has some limitations. The first of these is that the data analysis was performed at a single Brazilian collection center, which partially limits generalizing the results. Another limiting factor is that the data collection on medical-hospital materials, exams, and medications was performed retrospectively from the patients' physical medical records, which makes data collection dependent on the quality of the records of the professionals involved in patient care.

Moreover, this study included only a few indirect costs, which could be carried out within the time frame foreseen for the study. However, other costs exist and can be incorporated into future studies, such as property depreciation, the security system, software usage licenses, taxes, the material and sterilization center, ongoing education for professionals working in the *OPO* and ICU, among others, in addition to direct costs which may not have been identified in this study.

Another limiting factor is the lack of studies that assess the costs of nondonors due to family refusal and physician refusal [6]. The few existing cost studies are of aggregated cost (macrocosting) and only focus on the actual donor and the organ transplantation cost as a whole, and not on the cost during the period in which the donor remains in the ICU as a potential donor/eligible donor until the outcome [28].

Therefore, it is suggested that more economic evaluation studies be conducted through microcosting analysis, which address this issue in the global scenario, so that the costs incurred by the actual donor and nondonor are recognized by civil society, health professionals, public authorities, and legislators, and there can be greater control of health budgets and optimized use of resources. Studies that exclusively assess the actual donor cost in the surgical center during organ and tissue removal are also suggested.

Despite the few limitations, this study has a strong point in that it is the first to analyze the cost of effective donors and nondonors using the TDABC method. The analysis presented is intended to support decision-making and planning of health resource management in the area of transplants in order to make them more effective, both in Brazil and in other countries.

CONCLUSION

The composition of costs related to maintenance of organ and tissue donors and nondonors in relation to all outcomes was mainly related to the cost of health professionals, followed by tests, medications, and hospital supplies.

When comparing the length of stay in the ICU after a BD diagnosis, effective donors remained for a longer time when compared to the other outcomes. Effective donors were predominantly victims of hemorrhagic vascular events. In contrast, nondonors were mostly male, over 55 years of age, and, similar to effective donors, victims of hemorrhagic vascular events.

Reviews of work processes and strategies to mitigate failure to donate organs in all outcomes are necessary, since the sum of the amounts spent on medical refusal, family refusal, and problems preventing collection totaled US$104,121.66 in 1 year of study and in a single authorized center.

DATA AVAILABILITY

Data will be made available on request.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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