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ORIGINAL PAPER

Evaluation of the Cost of Liver Transplantation in a Hospital Providing Care under the Brazilian Unified Health System

Mara Rúbia de Moura[1], Bárbara Buitrago Pereira[1,*], Agnaldo Soares Lima[1]

1.Santa Casa de Belo Horizonte – Setor de Transplante Hepático – Belo Horizonte (MG) – Brazil.

*Corresponding author: barbarabuitragop@hotmail.com

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ABSTRACT

Introduction: Liver transplantation is considered an expensive procedure due to its complexity and the fact that it is predominantly performed on critically ill patients. In general, the management of hospital costs and the allocation of resources for public health have garnered increasing attention over the years. **Objectives:** This study aims to analyze the costs associated with liver transplantation to facilitate interventions that improve the cost-effectiveness of the procedure. **Methods:** This is a cross-sectional study conducted in a large philanthropic hospital. Patients aged 18 years or over who underwent liver transplantation in the service were included, yielding a sample of 86 patients. Direct and indirect costs related to care were analyzed, and potential factors associated with increased procedure costs were studied. **Results:** The sample comprised 76% male, with a median age of 56 years. The one-year survival rate was 71%, and the median length of hospitalization for transplantation was 15 days. The total cost calculated for this sample was BRL 13,049,707.72, with the largest portion (58%) attributable to the daily rates of the intensive care unit and inpatient ward. The total revenue was BRL 11,189,072.36. Even with a 60% incentive increase in the payment schedule, the operational contribution margin remained negative in all scenarios. Factors statistically associated with total costs were the average hospital stay ($p < 0.0001$) and outcome (alive or deceased) ($p = 0.001$). The results reveal a lack of financial sustainability in the context of liver transplantation funded by the Brazilian Unified Health System (SUS). Nationally, the findings of this study have the potential to inform the creation of sustainable programs that promote patient access to effective treatment. Furthermore, these results may serve as a reference for financial analysis methodology in other transplant centers, contributing to a more efficient and equitable approach to healthcare resource management. **Conclusion:** The cost of hospital care for liver transplantation, over one-year post-transplant, exceeds the payment made by the SUS, even at the highest incentive level, as of September 2023.

Descriptors: Liver Transplantation; Hospital Costs; Costs and Cost Analysis.

Análise do Custo do Transplante Hepático em um Hospital de Nível Terciário do Sistema Público no Brasil

RESUMO

Introdução: O transplante hepático é considerado um procedimento dispendioso, devido à sua complexidade e ao fato de ser realizado majoritariamente em pacientes gravemente enfermos. De modo geral, o gerenciamento dos custos hospitalares e o aporte de recursos destinados à saúde pública têm ganhado atenção crescente ao longo dos anos. **Objetivos:** Este estudo tem como objetivo analisar os custos associados ao transplante de fígado, com o intuito de possibilitar intervenções que melhorem o custo-benefício do procedimento. **Métodos:** Trata-se de um estudo retrospectivo realizado em hospital filantrópico de grande porte, incluindo 86 pacientes transplantados no serviço, todos com 18 anos ou mais. Foi realizado levantamento dos custos relacionados à assistência e estudados os possíveis fatores relacionados ao aumento dos custos do procedimento. **Resultados:** A amostra foi constituída em 76% por pessoas do sexo masculino e teve mediana de idade de 56 anos. A sobrevida ao final de 1 ano foi de 71%, e o tempo de internação do transplante teve mediana de 15 dias. O custo total calculado dedicado a essa amostra foi de R$ 13.049.707,72, sendo a parcela mais importante (58%) referente às diárias de unidade de terapia intensiva e enfermaria. A receita total foi de R$ 11.189.072,36. Considerando o acréscimo na tabela, incentivo de 60%, a margem de contribuição operacional ainda foi negativa em todos os cenários. Os fatores estatisticamente relacionados aos custos totais foram o tempo médio de permanência hospitalar ($p < 0,0001$) e o desfecho (vivo ou falecido) ($p = 0,001$). Os resultados obtidos revelam falta de sustentabilidade do transplante hepático financiado pelo Sistema Único de Saúde (SUS). Em âmbito nacional, as descobertas deste estudo têm o potencial de informar, permitindo a criação de programas sustentáveis que promovam o acesso dos

pacientes a um tratamento efetivo. Além disso, esses resultados podem servir como referência para a metodologia de análise financeira em outros centros de transplante, contribuindo para uma abordagem mais eficaz e equitativa na gestão de recursos em saúde. **Conclusão:** O custo do tratamento hospitalar do transplante hepático, ao longo de 1 ano pós-transplante, é superior ao pagamento efetuado pelo SUS, mesmo no maior nível de incentivo oferecido até setembro de 2023.

Descritores: Transplante Hepático; Custos Hospitalares; Custos e Análise de Custo.

INTRODUCTION

Liver transplantation is an effective treatment for patients in the final stages of chronic or acute liver disease, improving survival and quality of life for patients undergoing this procedure. Approximately 96% of these transplants are financed entirely by the Brazilian Unified Health System (*Sistema Único de Saúde* - SUS), which includes the dispensing of immunosuppressants used after the procedure.[1,2] With the increase in the number of transplants performed, special attention has been given to medical and hospital financial expenses and, mainly, to funds allocated to public health.

Although it is already consolidated as an effective treatment for liver failure, liver transplantation is still considered very expensive[3]. The high costs of the procedure reflect not only its complexity but also the fact that transplantation is performed, in most cases, on seriously ill patients. Concerns about the high cost of liver transplantation have limited its indication in many developing countries despite its widely documented benefits. In addition, it is vital to consider the low quality of life of non-transplanted patients and the inherent cost of alternative clinical and/or surgical care that must be provided to patients with liver disease[4].

Advances in liver preservation, surgical techniques, prophylaxis and treatment of secondary infections, and improved control of rejection have contributed to the positive results of liver transplantation and its widespread international acceptance. However, it is essential to closely monitor all costs associated with these procedures, including an analysis of revenue sources and any surplus margin, i.e., the profit that recovers the capital employed.[3]

Considering the complexity involved in its implementation and the high national demand, the objective question is what the hospital costs related to liver transplantation are in our setting. Few studies address direct and indirect consumption related to the procedure and evaluate potential predictive factors of the increase in these costs. A thorough and detailed analysis of the cost can serve as the basis for discussions that stimulate institutional growth, as this procedure can be configured as strategic financing, allowing for investment not only in the transplant service but also in other hospital units that support its operation. At the national level, the study can support the development of sustainable programs that promote patient access to effective treatment and serve as a reference for financial analysis methodologies in other transplant centers.

The objective of this study, therefore, is to analyze the hospital costs related to liver transplantation with deceased donors within 12 months after the transplant, in addition to evaluating characteristics of the recipients that may be related to the increase in costs.

METHODS

This study is a retrospective longitudinal evaluation of the costs associated with liver transplantation performed at *Santa Casa de Belo Horizonte* (SCBH), which initiated its transplant service in 2016.

For this purpose, the inclusion criteria were liver transplants performed in the service from 2016 to 2021, with an interval of at least 12 months between the procedure and the time of data collection, regardless of the patient's outcome during this period. In addition, only recipients aged 18 years or older were included. The exclusion criteria were patients who underwent transplantation of more than one organ simultaneously, and patients referred for retransplantation in less than 1 year.

The 1-year follow-up period enables the analysis of costs associated with both immediate and late post-procedure readmissions. Additionally, it establishes a balance in the cost analysis, as this is the period with the highest probability of complications.

For the financial analysis of the actual costs of liver transplantation, a survey was conducted to assess the direct and indirect costs associated with care. Fixed and prorated costs were considered for the sectors that are part of the patient's care line, such as the surgical block, intensive care unit (ICU), diagnostic testing sector, and inpatient unit.

Direct costs were considered to include all materials, medications, solutions and blood products used, orthoses and prostheses, medical and non-medical remuneration, laboratory materials, hemodialysis, provision of services, foodstuffs, packaging, personal protective equipment (PPE), maintenance and hotel materials, maintenance and installation services, general expenses such as electricity, water, telephone, printing services, allowances, and freight/transportation. The costs of pre-hospitalization services,

clinical nutrition, clinical pharmacy, management of the high-complexity unit, and skin integrity and dentistry services were considered indirect costs of the institution. These data were obtained from patient statements in the Hospital Management System (*Sistema de Gestão Hospitalar* - SGH) and the Key Performance Indicators of Health (KPIH), some of which were calculated directly. In contrast, others were calculated through the apportionment of monthly expenses.

It is essential to note that the analysis presented in this study is limited to institutional transplant costs. In this case, indirect extra-hospital costs, such as patient transportation provided by the municipality's Health Department, expenses for medication supplied by the Health Department, and costs related to patient productivity loss, were not included in this analysis.

After evaluating the direct and indirect costs of the institution, the values were divided by the number of patients per day, according to the place of hospitalization (ICU and ward), thus calculating the daily cost of each unit. This calculation complemented the total cost of hospitalization, taking into account the length of stay for each patient.

In addition, the financial transfer values for the procedures performed by these patients were made under the Management System of the Table of Procedures, Medications, and Orthoses, Prostheses, and Special Materials (*Sistema de Gerenciamento da Tabela de Procedimentos, Medicamentos e Órtese, Prótese e Materiais Especiais*-OPME) of the SUS (SIGTAP).

To calculate the transfer of professional services, the amounts recorded in patient statements by the billing department were considered, along with the current contracts of the service providers and/or legal entities.

Data collection was performed through the billing module in the SGH and KPIH used for financial recording and hospitalization control. The hospital's controller department analyzes the costs. For the analysis, the controllers used the complete absorption costing method. According to this method, each hospital unit was considered a cost center to which resources are allocated to cover services provided by in-house professionals or third parties (labor costs), materials, and direct or indirect overhead expenses.

After obtaining the median, minimum, and maximum costs for each department involved in the transplant, a univariate sensitivity analysis was performed on the observed expenses for each cost component, allowing for an inference regarding the departments with the most significant impact on the total cost.

For comparative analysis of costs concerning the characteristics of the recipients, donors, and the procedure, the following variables were considered: age and sex of the recipient, underlying liver disease, nutritional diagnosis, calculated and attributed Model for End-Stage Liver Disease - Sodium (MELD-Na) value, the need or not for hospitalization before the surgical procedure, donor age, organ ischemia time, length of hospital stay during the transplant admission and subsequent readmissions and the outcome at the end of 12 months (alive or death).

Regarding the underlying liver disease, the following subgroups of etiologies were considered: biliary cirrhosis, hepatocyte cirrhosis, metabolic cirrhosis, and others. The severity of the liver disease was analyzed according to the calculated and assigned MELD-Na score, as this score predicts mortality in patients with advanced liver disease within 3 months and is the primary factor used to allocate patients to the transplant waiting list. Regarding the nutritional diagnosis of the recipients, they were classified as eutrophic, malnourished, overweight, obese, or unclassified, according to the clinical analysis performed and recorded in the medical records by the hospital nutrition team.

These clinical data regarding recipients, donors, and hospitalizations were obtained from the transplant service database (Zeus program) and the hospital's medical record system, PEP MV.

The data were submitted for calculations and statistical analyses using the Statistical Package for Social Sciences (SPSS) software, version 29.0.0.0. Categorical variables were analyzed descriptively, and continuous variables were tested for normality using the Shapiro-Wilk test. These variables were described by central tendency (median) and measures of dispersion, including the minimum and maximum interquartile ranges (IQR). The operational contribution margin (OCM) was analyzed, considering liver transplantation as a business unit to determine the real result, that is, net revenue minus total cost[5]. Pearson's chi-square test was used to determine the association between the outcome and the cost of the transplant, as well as the categorical independent variables. Bilateral hypothesis tests were performed between the length of stay and the total cost, using the independent continuous variables, with the nonparametric Mann-Whitney and Kruskal-Wallis tests. For the analyses, a 95% confidence interval (95%CI) with a significance level of 0.05 was considered.

Before its execution, the research project was submitted to and approved by the Research Ethics Committee of SCBH under the opinion of CAAE: 20085919.0.0000.5138.

RESULTS

A total of 103 transplants performed from March 2016 to February 2021 were identified, which were at least 12 months postoperative at the time of data collection, carried out in 2022. Of these, 11 patients under 18 years of age were excluded, two due to double transplantation and four due to retransplantation. Therefore, the sample analyzed consisted of 86 cases.

Among these, there was a prevalence of males (75.6%), and the ages ranged from 18 to 70 years, with a median of 56 years (IQR = 19.5 years). The primary etiology of liver disease was hepatocyte cirrhosis (79.1% of cases). The calculated MELD-Na ranged from 9 to 50 with a median of 19.5 (IQR = 7.0). The assigned MELD-Na values, in turn, ranged from 16 to 50, with a median of 20 (interquartile range [IQR] = 3.0). The age of donors ranged from 12 to 69 years, with a median age of 49 years (interquartile range, IQR = 22.9 years). The ischemia time of the transplanted organ ranged from 289 minutes to 864 minutes, with a median of 441.9 minutes (interquartile range, IQR = 158.0 minutes).

The one-year survival rate in the analyzed sample was 70.9%. Of the patients alive at the end of 1 year, 89.7% required readmissions, ranging from one to seven times in the 1st year after transplantation.

The length of stay in hospitalization for transplantation ranged from 1 to 129 days, with a median of 15 days (IQR = 16.5). Most patients (77%) were hospitalized for up to 30 days. The length of stay in readmissions, with a median of 14 days, ranged from 1 to 99 days.

Concerning the transplants analyzed, the total cost of the sample, adding up the costs of all procedures considered in the period, was BRL 13,049,707.72, subdivided into: 1) Cost of hospitalization (daily, in ward and ICU); 2) Costs of materials and medications; 3) Costs of medical payments; 4) Costs of examinations performed; and 5) Cost of surgical block hours, as described in Table 1.

Table 1. Stratification by subgroups of liver transplant costs (n = 86).

Group	Total cost (BRL)	%
Hospitalization (daily ICU and ward stay)	7,581,251.40	58
Materials and medicines	2,635,036.17	20
Medical payment	1,599,178.26	12
Examinations	867,365.89	7
Surgical unit	366,876.00	3
Total cost	13,049,707.72	100

Source: Elaborated by the authors

The total cost per transplant per patient, which encompasses both direct and indirect costs, ranged from BRL 33,729.82 to BRL 505,372.17, with a median of BRL 117,355.15 (IQR = BRL 125,867.60). Transplant costs per patient were also stratified by sector, as explained in Table 2.

Table 2. Stratification of transplant costs by patient.

Costs	Maximum (BRL)	Minimum (BRL)	Median (IQR) (BRL)
Hospitalization (ICU/ward)	384,825.00	1,440.00	62,949.50 (86,997.00)
Materials and medicines	99,427.00	2,915.71	24,589.00 (30,176.50)
Medical payment	35,907.29	10,385.52	17,654.50 (962.5)
Examinations	52,064.40	792.49	6,118.50 (10,433.00)
Surgical unit	11,372.00	1,715.00	3,828.00 (1,980.25)
Total cost	505,372.20	33,729.80	117,355.15 (125,867.60)

Source: Elaborated by the authors

A univariate cost sensitivity analysis was performed using the minimum and maximum values observed in each component in Table 2. It was observed that the item with the most significant impact on the total cost was the daily hospitalization fee, whose isolated variation could alter the total cost of a transplant from BRL 117,355.15 to up to as high as BRL 439,230.65, or as low as BRL 55,845.65. Other components, such as materials, medications, and the cost of tests, also exhibited significant cost variations (Table 3).

Table 3. Univariate cost sensitivity analysis.

Component	Total base cost (BRL)	Minimum total cost (BRL)	Maximum total cost (BRL)
Daily hospitalization rates	117,355.15	55,845.65	439,230.65
Materials and medicines	117,355.15	95,681.86	192,193.15
Medical payment	117,355.15	110,086.17	135,607.94
Examinations	117,355.15	112,029.14	163,301.05
Surgical unit	117,355.15	115,242.15	125,899.15

Source: Elaborated by the authors

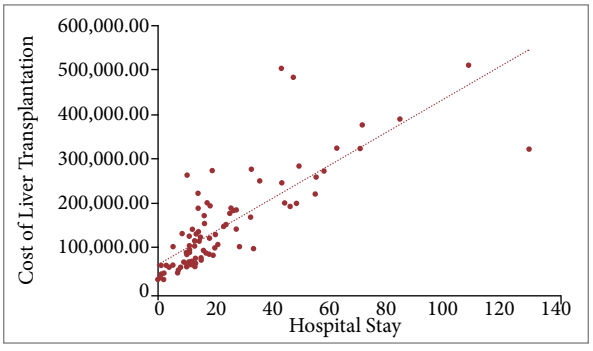
Regarding the variables potentially related to the cost of transplantation, only hospital stays longer than 20 days and the outcome at the end of 1 year were found to be statistically significant (Table 4).

Table 4. List of characteristics of the recipient, donor, procedure and transplant costs.

Variables	Transplant costs		*p*-value
	Less than median	Greater than median	
Sex			
Female	10	11	0.802
Male	33	32	
Age (years)			
18 to 30	5	3	0.632
31 to 40	3	7	
41 to 50	6	4	
51 to 60	12	13	
61 to 70	17	16	
Diagnosis			
Biliary cirrhosis	2	7	0.073
Hepatocyte cirrhosis	34	34	
Metabolic cirrhosis	4	0	
Others	3	2	
MELD-Na calculated			
< 18	18	21	0.281
18 to 24	13	16	
≥ 25	12	6	
MELD-Na assigned			
< 18	8	8	0.284
18 to 24	22	28	
≥ 25	13	7	
Nutritional diagnosis			
Eutrophic	14	12	0.160
Malnourished	7	12	
Overweight	7	8	
Obese	10	11	
Not rated	5	0	
Hospitalization before transplant			
Yes	38	39	0.500
No	5	4	
Hospitalization (days)			
< 20	41	19	**< 0.001**
≥ 20	2	24	
Outcome			
Alive	24	37	**0.002**
Death	19	6	

Source: Elaborated by the authors. Bold values indicate a statistically significant difference ($p < 0.05$).

A significant association was observed between the length of the patient's hospital stay and the total cost of liver transplantation ($p < 0.001$), as shown in Figure 1.



Source: Elaborated by the authors

Figure 1. Scatter diagram between total length of hospital stay (days) and total cost of treatment (BRL) of patients undergoing liver transplantation.

The influence of the outcome at the end of 1 year is more specifically evident in the costs of hospitalization, examinations, and the surgical unit, as shown in Table 5. It can be seen that the costs of hospitalization, examinations and the surgical unit are significantly lower in patients who died earlier.

Table 5. Relationship between 1-year outcome and cost by subgroup.

Costs	Outcome in 1		-year *p*-value
	Alive (BRL)	Death (BRL)	
Daily hospitalization rates	83,800.00	27,960.00	**< 0.001**
Exams	6,845.00	4,948.00	**0.038**
Materials and medicines	24,873.00	21,914.00	0.658
Surgical unit	4,140.00	3,271.00	**0.028**
Medical professional	17,697.00	17,488.00	0.618

Source: Elaborated by the authors. Bold values indicate a statistically significant difference ($p < 0.05$).

The amounts transferred by the SUS, referred to as Financial Increase for Carrying out Transplant Procedures and the Organ Donation Process (*Incremento Financeiro para a Realização de Procedimentos de Transplantes e o Processo de Doação de Órgãos*- IFTDO)[6], depend on the classification of institutions by levels, ranging from A to D, according to predetermined criteria. The institution where the research was conducted is classified as level A (60% incentive). The institution's revenue, considering the receipt of a 60% incentive, ranged from BRL 110,103.60 to BRL 236,472.80, with a median of BRL 118,139.08 (IQR= BRL 22,400.10) per transplant.

The MCO for liver transplantation ranged from - BRL 355,676.30 to BRL 105,514.80, with a median of BRL 9,249.97 (IQR = BRL 103,273.02). As revenue did not vary with the outcome presented by the patient, the contribution margin was significantly affected, being higher in patients who died during the analyzed period (Table 6).

Table 6. Relationship of revenue and MCO with patient outcome.

Costs	Outcome in 1		-year *p*-value
	Alive (BRL)	Death (BRL)	
Median revenue with incentive 60% (IQR)	117,779.19 (18,577.74)	122,371,26 (39,215.84)	0,903
MCO Median (IQR)	- 12,473.62 (93,707.87)	51,392,58 (39,722.74)	**< 0,001**

Source: Elaborated by the authors. Bold values indicate a statistically significant difference ($p < 0.05$).

When evaluating the total sample studied as a business unit, the following results are obtained: Total revenue BRL 11,189,072.36- Total cost R$ 13.049.707,72 = MCO -BRL 1,860,635.36.

Table 6 presents a simulation between the different types of incentives, including the most recent maximum incentive of 80%. The 80% increase is based on the new form of incentive granted since September 2023 (Ordinance GM/MS No. 1.262) for transplant services classified as Level A. The corrected values related to readmissions throughout the 1st year were not included in the calculations in Table 7.

Table 7. MCO according to the incentive level.

Classification	Revenue (BRL)	Costs (BRL)	MCO (BRL)	% coverage costs
No incentive	6,993,170.23	13,049,707.72	- 6,056,537.49	54
30% incentive	9,091,121.29	13,049,707.72	- 3,958,586.43	70
40% incentive	9,790,438.32	13,049,707.72	- 3,259,269.40	75
50% incentive	10,489,755.34	13,049,707.72	- 2,559,952.38	80
60% incentive	11,189,072.36	13,049,707.72	- 1,860,635.36	86
80% incentive*	12,587,706.41	13,049,707.72	- 462,001.30	96

Source: Elaborated by the authors. * The 80% incentive is a simulation and is not part of the survey in this study.

DISCUSSION

The mean age of transplant patients in this study is similar to that found in other studies, in which it ranged from 46 to 68 years. Males were the most prevalent in the sample of this study. Similar results were found in other studies conducted in southern

Brazil and Turkey, which observed a prevalence of males in the order of 62.4% and 70.6%, respectively[3,7]. Regarding the etiology of the underlying disease, the patients presented hepatocyte cirrhosis as their primary diagnosis, a diagnosis also found in most studies[3,7,8]. Chronic hepatitis virus infection is the leading cause of hepatocellular carcinoma and cirrhosis, which are the main indications for liver transplantation globally[9]. The severity of liver disease, assessed by the calculated MELD-Na, had a median value of 19.5, a finding consistent with data from national and international studies, which reported averages ranging from 16.7 to 24.3[3,8,10]

This study reported a median cost of liver transplantation of BRL 117,355.15 per patient. To facilitate comparisons with other studies, particularly international studies, transplant costs can be converted to international dollars adjusted for purchasing power parity (US$ PPP) using the World Bank's conversion factors. This analysis enables a more accurate approach to variations in procedure costs across different economic contexts.

Considering that the study covers transplants performed between 2016 and 2021, a conversion factor of 2.28 was used, referring to the average Purchasing Power Parity (PPP) exchange rate during this period. Thus, the cost of the transplant in the period considered for comparison purposes was US$ 51,468.75 PPP.

Several studies conducted worldwide have shown variations in the costs of the procedure. In southern Brazil, a study evaluating transplants performed from 2013 to 2014 showed an average cost per patient of BRL 58,699.00 (25,654.58 US$ PPP), while the Northeast region, in 2010, showed an average cost of BRL 51,255.15 (24,059.71 US$ PPP)[3,11]. It is worth noting that the difference in the period analyzed is a crucial factor to consider in the differences in values between the studies, as inflation and price adjustments over the years have a significant impact on costs.

These variations may also have occurred due to issues related to the cost analysis method and difficulties in allocating indirect costs, given that hospital billing records were analyzed.

Data from international studies present values in dollars, which can sometimes make it difficult to compare costs with those in Brazil, especially in cases where the values are not converted from dollars to international dollars using purchasing power parity (PPP). The average cost of transplants performed in Argentina from 2006 to 2010 was US$ 33,461.00, and in Turkey, from 1999 to 2009, US$ 27,582.00[7,8]. Other national studies, which presented costs in dollars, observe a similar margin to global studies, with averages of US$ 21,505.53 (1995 data) and US$ 20,605.0 (2007 data)[4,12].

A key strength of this study is its comprehensive and specialized approach to cost assessment. Among the literature analyzed it is observed that most studies do not stratify costs, confirming the premise that direct and indirect costs related to the procedure may not have been considered. The lack of a standard method and items to be evaluated and included in the total cost estimate may also have been a factor closely determining the final value of the analyses found in the literature.

The lack of stratification of direct and indirect costs of transplantation in articles on the price of liver transplantation in Brazil and worldwide is a significant issue that deserves attention in the discussion on this topic. This lack of detail and standardization in cost analysis can have several implications, both in the interpretation of results and in decision-making related to health policy and resource allocation.

The lack of a clear distinction between direct and indirect costs may lead to an underestimation or overestimation of the total costs of liver transplantation. Direct costs include specific medical and hospital expenses related to the procedure, such as surgery, medications and hospitalization. Some direct costs, mainly fixed costs, are difficult to allocate directly to the account, requiring the definition of apportionment methods. In contrast, indirect costs include transportation, accommodation and other costs indirectly associated with the transplant. Without a detailed analysis of these costs, it isn't easy to obtain an accurate picture of the resources required to perform the procedure effectively.

In the present study, it was challenging to measure indirect extra-hospital costs, such as patient transportation and accommodation, which were therefore excluded from the analysis. Regarding direct expenses, it was possible to stratify the various sectors. Still, the analysis of transplant hospitalization versus subsequent readmissions was not performed separately, a factor that could also contribute to an even more effective analysis.

Upon closer examination of transplant expenses, it is observed that the primary cost is associated with the patient's hospitalization expenses. In this study, this item accounts for 58% of the total calculated cost. The univariate cost sensitivity analysis performed in this study shows that the item with the most significant impact on the total cost was the daily hospitalization fees, whose isolated variation could change the total cost of a transplant from BRL 117,355.15 to as high as BRL 439,230.65 or as low as BRL 55,845.65. This result reinforces the importance of managing the length of hospitalization and postoperative complications as essential factors for controlling liver transplant costs.

Other components, such as materials, medications and test costs, also showed significant cost variation. Considering that expenses with materials, medications and tests are those that undergo the highest rates of adjustment over the years, their potential influence on transplant costs can be considered even greater. Thus, the rational use of available medications and tests also becomes relevant in controlling costs related to a procedure as complex as liver transplantation.

In a study conducted at a hospital in the United States, it was observed that hospitalization costs for transplants accounted for approximately 50% of the total cost[8]. International studies indicate higher costs associated with complicated hepatitis B virus (HBV) infection and complicated hepatitis C virus (HCV) infection[7,13]. However, the relationship between the etiology of liver disease and the cost of transplantation was not observed in the present study.

The median length of hospital stay for patients at the study institution was similar to that in other studies conducted in Brazil and worldwide. These presented averages ranging from 11 to 51 days[3,4,12,14]. It is known that the length of hospital stay is directly linked to several factors, including comorbidities, nutritional status, MELD score, surgery, and postoperative conditions. Additionally, a study has correlated a more extended hospital stay with a higher MELD score[13].

Length of stay showed a significant difference in liver transplant costs. In a study that evaluated the cost of liver transplants at a university hospital in southern Brazil in 2019, it was observed that complications resulting from the transplant, as well as increased length of hospital stay, had a significant impact on the final costs of the procedure, especially for those patients who presented septic shock, acute coronary syndrome and post-transplant renal failure[3]. Regardless of the type of complication, it is known that hospitalization costs are directly related to procedures, materials, length of stay, and professional demand for care. Thus, it is expected that costs will be higher in patients with longer hospitalization times and a history of frequent readmissions. Regarding the time between admission and the date of the patient's death, the present study presented data similar to other studies that demonstrated an average of 18 days[4].

When considering the institution's MCO, taking into account the revenue and direct and indirect costs of liver transplantation, a negative result of -BRL 1,860,635.36 is observed in the total sample of this study. When simulating the study's costs with the different levels of incentives offered as revenue, the MCO becomes even more negative, reaching -BRL 6,056,537.49.

On September 14, 2023, Ordinance No. 766 came into force, which promoted the update of the National Registry of Establishments, bringing significant changes to the financial increase values of the National Transplant System (*Sistema Nacional de Transplantes-SNT*)[15]. In addition, this regulation introduced a substantial expansion of the procedure codes eligible to receive this increase.

This study was conducted before the implementation of this ordinance; therefore, the data obtained do not yet refer to the receipt of this increase. Still, a simulation involving the new payment method was included, in which the institution began to receive an 80% increase under the guidelines of the new regulation (classified as A) (Table 7). The presented represents a significant milestone in establishing a considerable balance among business units within the context of the transplant system, generating a positive impact in terms of financing and support for transplant-related operations.

With the review of financing related to liver transplants, there is a trend towards sustainability of the procedure. However, continuous monitoring should be established to promote not only continuity but also growth in the performance of this procedure.

It is essential to note that associated costs may vary significantly depending on the institution in question and the approach adopted for contract management and service provision. This includes expenses related to tests and blood components.

The main limitation of this study was its retrospective nature, which limits the collection of all data regarding the costs of the procedure, especially indirect costs. Furthermore, the study did not separately evaluate expenses for each year, which may have influenced the results, considering the differences in inflation, currency exchange rates, and the value of the PPP conversion factor each year, thereby limiting comparisons with other studies. It is suggested that prospective analysis studies be developed, stratifying costs in even greater detail by period and by type of cost involved in the transplant.

This study was not specifically designed to analyze readmissions. It is, therefore, essential to emphasize the importance of continuing this type of study, particularly in terms of detailing data on hospitalizations, including the types of complications that occurred after the procedure and the costs associated with caring for each subtype of complication. A detailed investigation of these elements can contribute to obtaining more comprehensive data and analyzing potential points for strategic improvement within the institution, which can impact the costs of the procedure.

CONCLUSION

The total hospital cost measured in this study with 86 transplants in a 12-month post-transplant follow-up period was BRL 13,049,707.72, with the highest cost related to hospitalization, followed by materials and medications. The average length of hospital stay and patient outcome significantly impacted the cost of transplantation. The other characteristics of the disease and patients did not directly correlate with the cost of transplantation. The MCO was negative at all incentive levels, while the cost of hospital treatment for liver transplantation over 1-year post-transplantation was higher than the payment made by the SUS, even at the highest incentive level established as of September 2023.

CONFLICT OF INTEREST

Nothing to declare.

AUTHOR'S CONTRIBUTION

Substantive scientific and intellectual contributions to the study: Lima AS, Moura MR, Pereira BB; **Conception and design:** Moura MR; **Data analysis and interpretation:** Lima AS, Moura MR, Pereira BB; **Article writing:** Moura MR, Pereira BB; **Critical revision:** Lima AS, Pereira BB; **Final approval: P**ereira BB.

DATA AVAILABILITY STATEMENT

All dataset were generated or analyzed in the current study.

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