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Analysis of Access to Liver Transplantation in Different Brazilian Regions from 2018 to 2022: A Cross-Sectional Study

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ABSTRACT

Introduction: Although the simulated liver allocation model for liver transplantation has enabled a more equal distribution of surgeries in Brazil, it remains a subject of controversy whether access to the procedure is fair across various regions of the country. To assess this, data from patients who moved to different regions to undergo liver transplants were analyzed. **Methods** A retrospective cross-sectional study was carried out on liver transplantation using the Brazilian Unified Health System's IT department (DATASUS) data from 2018 to 2022, and sorted the procedures/patients by region using Software PAST 4.12 (University of Oslo). **Results:** 88,78% (n = 198) of patients from the northern region needed to migrate, while in the central-west region, 23.39% (n = 84) of patients needed to migrate to other regions. In three states of the northeast region, 100% (n = 117) of the patients needed to migrate to states within the same region. In Tukey's pairwise test: Midwest and Southeast p=0.03, North and Southeast p=0.008, Northeast and Southeast p= 0.02. **Conclusions:** There is a noticeable disparity in access and the need for patient migration from the North, Northeast, and Central-West regions, which may affect the prognosis and result in extra expenses for patients from these regions.

Descriptors: Transplantation; Brazil; General Surgery; Equity.

Análise do Acesso ao Transplante de Fígado nas Diferentes Regiões Brasileiras de 2018 a 2022: Um Estudo Transversal

RESUMO

Introdução: Embora o modelo simulado de alocação de fígado para transplante tenha permitido uma distribuição mais igualitária das cirurgias no Brasil, ainda é motivo de controvérsia se o acesso ao procedimento é justo nas diversas regiões do país. Para avaliar isso, analisamos dados de pacientes que se mudaram para diferentes regiões para serem submetidos a transplantes de fígado. **Métodos:** Realizamos um estudo transversal retrospectivo sobre transplante de fígado utilizando dados do departamento de informática do Sistema Único de Saúde (DATASUS) de 2018 a 2022, e classificamos os procedimentos/pacientes por região usando o Software PAST 4.12 (Universidade de Oslo). **Resultados:** 88,78% (n = 198) dos pacientes da região Norte necessitaram migrar, enquanto na região Centro-Oeste, 23,39% (n = 84) dos pacientes necessitaram migrar para outras regiões. Em três estados da região Nordeste, 100% (n = 117) dos pacientes necessitaram migrar para estados da mesma região. No teste de Tukey pareado: Centro-Oeste e Sudeste p=0,03, Norte e Sudeste p=0,008, Nordeste e Sudeste p= 0,02. **Conclusões:** É perceptível a disparidade no acesso e a necessidade de migração de pacientes das regiões Norte, Nordeste e Centro-Oeste, o que pode afetar o prognóstico e resultar em gastos extras para os pacientes dessas regiões.

Descritores: Transplante; Brasil; Cirurgia Geral; Equidade.

INTRODUÇÃO

The inaugural liver transplantation procedure took place in Brazil in 1985, encompassing an extensive surgical duration of approximately 23 hours at the distinguished Hospital das Clínicas – SP[1]. This notable milestone followed a span of 22 years subsequent to the world's inaugural liver transplant in 1963, orchestrated by the accomplished physician Thomas Starzl and his adept team in Denver, United States[2]. Rapid advancements have since transpired in the domain of liver transplantation, progressively establishing it as the quintessential therapeutic modality for both chronic and acute hepatic failure, irrespective of its etiology. Impressively, the cumulative tally of liver transplantation procedures conducted to date surpasses 80,000[3].

Nevertheless, evident disparities in the frequency of liver transplantations among divergent geographical regions have been extensively reported across several nations, encompassing Australia, Spain, the United States of America, France, and others[3]. Brazil, with its expansive territorial expanse, is not immune to this phenomenon, thereby intensifying the predicament. Consequently, in 2006, Brazil embraced the adoption of a comprehensive framework for the ordering of liver transplant waiting lists, predicated on the Model for End-Stage Liver Disease (MELD) or the Model for Terminal Liver Diseases, which also accommodates instances of exceptional circumstances[4]. However, the intricate interplay of social determinants of health, notably encompassing socioeconomic factors, regional differentials, and cultural nuances, remains a formidable barrier, impeding equitable access to the sphere of secure hepatic surgical interventions[4].

METHODS

Design

This is a transversal and descriptive study, based on secondary data research, carried out through the information technology department of the Brazilian Unified Health System (DATASUS)[6]: An agency of the Secretariat for Strategic and Participatory Management of the Ministry of Health, with the responsibility to collect, process and disseminate health information The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) cross-sectional study checklist was applied to conduct this research. Further tabulation and analysis were done through the Microsoft Excel® program.

Setting

Information was collected regarding the patient's place of residence (states) in Brazil and the place of hospitalization during, data collection updated October 10, 2022. This is an observational, cross-sectional and retrospective study using data from Brazilian Hospitalar Information System (in portuguese, SIH), through the Informatics Department of Brazilian Universal Healthcare System (in portuguese, DATASUS- TabNet). Data was analyzed from 2018 to 2022.

The scenario of this study was the country Brazil: North, Northeast, Midwest, South and Southeast. In total, Brazil has 26 states and a federal district. The data recruitment period was until October 10, 2022. Until that deadline, data were only available from April 2018, until April 2022. To access data on liver transplantation according to the region in that the surgeries were performed, see Fig. 1.

Participants

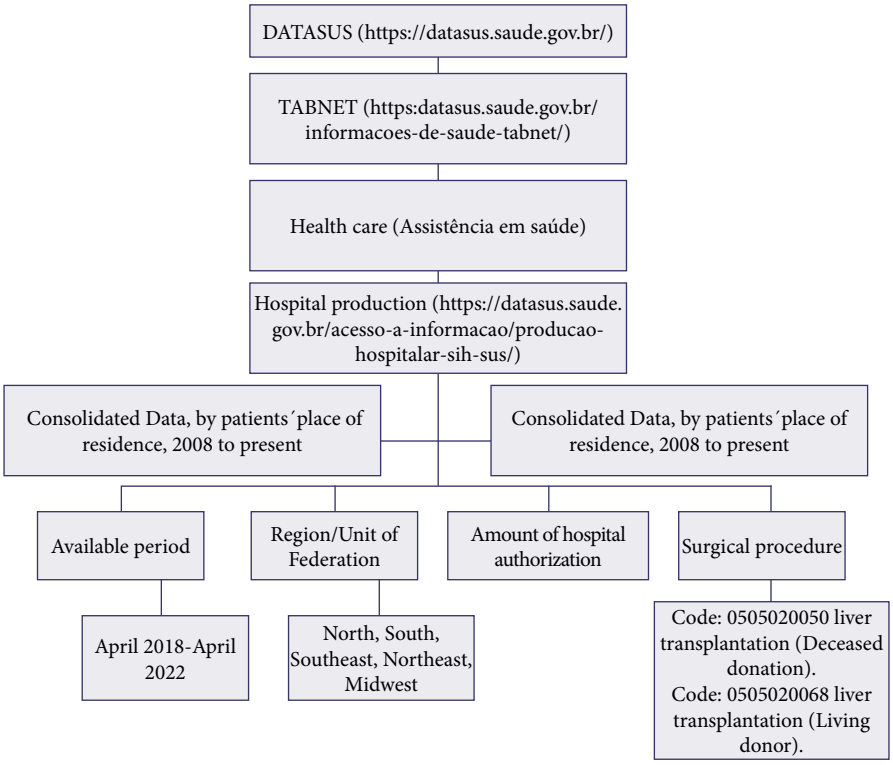
The data selected for this study met the following criteria, based on the PICo principle: People undergoing liver transplantation in Brazil from 2018 to 2022 (P- Population/Patient/Problem); Liver transplantation (I- Interest), Brazilian regions (Co- Context). In order to gather data regarding the place of hospitalization of patients and place of usual residence, the data were categorized by selecting ''Hospital procedures", ''Region/Unit of the federation", and ''hospitalization authorization", for liver transplant procedures (Organ from living donor and deceased donor) performed between April 2018 and April 2022. Sociodemographic data of patients undergoing liver transplantation, such as sex, age, gender, and ethnicity was not available.

Variables

Liver transplantation was thoroughly analyzed by geographic region and year (2018-2022) and the absolute number and per 100 000 inhabitant of digestive tract surgeons in each Brazilian state, updated by October 10, 2022. The authors adjusted for the following potential confounders and covariates: Impact of the pandemic covid-19 on performing surgeries, difference in the number of inhabitants, recipient sex, age, and race.

Data sources and measurement

To analyze the distribution of surgeons in Brazilian regions, the number of digestive system surgeons in each state of Brazil was verified on the website of the Federal Council of Medicine. To analyze the number of inhabitants in each region, the most recent IBGE (Brazilian Institute of Geography and Statistics), 2021, was followed. All data referring to the 7332 liver transplants were included in this research. Statistical analysis and measurement were performed on PAST, version 4.12.



Source : Elaborated by authors.

Figure 1. Flow diagram showing process of search and patients' selection.

Bias and Study size

To avoid sampling bias, it was decided to use absolute data and also the proportion for each Brazilian region. Through DATASUS and the inclusion criteria, a total of 7332 liver transplant surgeries was reached.

Quantitative variables and Statistical methods

Quantitative variables were evaluated using means and variance, using Levene's test and Tukey's pairwise test. Statistical analysis and measurement were performed with the PAST Software (Version 4.12, Natural History Museum, University of Oslo, Norway), analysis of variance was performed by one-way ANOVA and Tukey's multiple comparisons tests. A 95% confidence interval was considered. Differences in data that reached $p < 0.05$ were considered statistically significant.

Informed consent and ethical approval

In this study, a cross-sectional analysis was conducted utilizing eligible data procedures obtained from the publicly accessible database DATASUS. Therefore, it is important to note that the requirement for informed consent and ethical approval was not applicable. It is worth mentioning that the Ministry of Health provides comprehensive access to inpatient services data through DATASUS, which is considered public domain. As a result, patient identities remain safeguarded, and any research utilizing data from DATASUS adheres to ethical standards and regulatory approvals.

RESULTS AND DISCUSSION

Participants

A total of 7,332 procedures were considered in this research based on inclusion criteria, carried out in Brazil from April 2018 to April 2022.

Descriptive data

Data on the epidemiological profile of patients was not available on DATASUS. On the other hand, in the 2021 liver transplant monitoring report of the Brazilian Ministry of Health[6], there is information on the demographics of organ recipients. Based on this report, it can be inferred that 12,687 patients underwent liver transplant (TxH) from January 2000 to December 2014. The average

follow-up time for patients was 34.5 months and the median was 20 months. The majority of patients were male (65.4%), and the TxH was performed in the Southeast region of Brazil (57.0%). The majority of grafts came from deceased donors (90.0%), and about 60.0% of recipients were over 46 years of age. Most patients did not have a recorded skin color (85.2%). Among those who did, white was the most prevalent (10.0%)[6].

Outcome data and mean results

The 26 Brazilian states, in addition to the Federal District, make up the Federative Republic of Brazil. Geographically, the territory is divided into five major regions: North, Northeast, South, Southeast and Midwest[7].

In the Brazilian Unified Health System, public health actions and services are part of a regionalized and hierarchical network, combined with comprehensive care understood as an articulated and continuous set of preventive and curative actions and services, individual and collective, required for each case at all levels of system complexity[8].

North region

The states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima, and Tocantins collectively accommodated a total of 223 patients undergoing liver transplantation based on their place of residence. It is noteworthy that all states within the region had patients in need of liver transplantation. However, it is interesting to observe that only 25 individuals (11.21%) were hospitalized within the northern region for liver transplantation. Strikingly, the majority, comprising 198 patients (88.79%), were transferred to other regions of the country for their surgical procedures.

Northeast Region

Comprising 9 states, it's notable that 3 of them (Piauí, Rio Grande do Norte, and Sergipe), despite expressing the need for liver transplantation, remained without any procedures. Nevertheless, nearby states within the region accommodated this demand. The northeast region saw 1360 procedures (95.30%) performed in 3 states: Bahia, Ceará, and Pernambuco. Conversely, the initial demand from these states—Bahia, Ceará, and Pernambuco—stood at 1063 (77.65%).

Midwest region

In the context of the Midwest region, which encompasses three states, it is worth mentioning that a total of 359 patients exhibited a pressing requirement for liver transplantation. Regrettably, the execution of said procedures was limited to only 275 cases, resulting in 84 patients being necessitated to undergo transfers to alternative states. Notably, a singular city, namely Distrito Federal, undertook a commendable responsibility by conducting 244 of these transplants, accounting for a substantial majority of 88.72% within the region.

South and Southeast Region

The south and southeast regions performed a greater number of liver transplants than the demand in the region itself. It can be inferred, then, that both regions were able to serve their entire population and also non-resident patients, supplying the demand of neighboring regions.

In Table 1 it is possible to see the distribution of patients' candidates for liver transplantation separated by region. And in Table 2 the distribution of digestive tract surgeons in the country

Mean amount of procedures per 100 000 inhabitants between 2018 and 2022. Southeast Region: 3.99, Midwest Region: 1.64, South Region: 6.65, North Region: 0.13, Northeast Region: 2.47.

Statistical analysis

Statistical analysis was performed on PAST, version 4.12. Statistical significance was set to $p < 0.05$. By One-way ANOVA: Southeast Region: Average= 895.5, S^2= 79175. Midwest Region: Average = 68.75, S^2=13863.58. South Region: Average=674.3333, $S^2$104169.3. North Region: Average= 3.571429, S^2= 89.28. Northeast Region: Average = 158.5556, S^2 = 70400.28.

Bayes Factor: 3,724 substantials evidences for unequal means Welch. F test in the case of unequal variances: F=2,31, df=6,21, p=0,1686, Levene´s test for homogeneity of variance, from means p (same): 0,002084 Levene´s test, from medians p (same): 0,09242. Sum of sqrs between groups: 2,30765E06, p (same)= 0,01318.

In Tukey's pairwise test: There were significant differences in the comparison: Midwest and Southeast p=0.03806, North and Southeast p=0.008449, and between Northeast and Southeast p= 0.0274.

This study is important because it was possible to realize that although liver transplants are performed at satisfactory levels, regional disparities remain. In addition to these main findings, despite having the lowest density of surgical workforce in the country per 100,000 inhabitants according to Table 2, the Northeast region presented an average of procedures per 100,000 inhabitants higher than the average presented in the North Region. Which indicates that the disparity is not only motivated by the absence of professionals.

Table 1. Distribution of patients and hospitalizations for liver transplantation by federative unit between April 2018 and April 2022.

Region / State	Patients by place of residence	Inpatient in each state
North Region	223	25
Acre	52	25
Amapá	08	0
Amazônia	51	0
Pará	56	0
Rondônia	32	0
Roraima	14	0
Tocantins	10	0
Northeast Region	1.369	1.427
Alagoas	72	02
Bahia	168	148
Ceará	506	728
Maranhão	51	08
Paraíba	66	57
Pernambuco	389	484
Piauí	34	0
Rio Grande do Norte	54	0
Sergipe	29	0
Midwest Region	359	275
Distrito Federal	170	244
Goiás	97	31
Mato Grosso	55	0
Mato Grosso do Sul	37	0
Southeast Region	3.388	3.582
Espírito Santo	111	110
Minas Gerais	615	551
Rio de Janeiro	739	753
São Paulo	1.923	2.168
South Region	1.993	2.023
Paraná	1.028	1.047
Rio Grande do Sul	462	491
Santa Catarina	503	485
TOTAL	7.332	7.332

Source: DATASUS, 2022.

The key point of our work is that, despite the existence of a national health system, regional variations are one of the main contributors to health inequalities in the country. Similar records[14] have already shown that 153 transplant units were identified in 2017, with only 11.8% located in the Northern and Midwest regions. During the study period, 99,805 transplants were performed, ranging from 3,520 in 2001 to 8,669 in 2017. The highest number of transplants was concentrated in the Southern and Southeastern regions.

For example, the Southeast region was the one that performed the most liver transplants according to Table 1. According to the same table, the Southeast region performed 60.16% more transplants in absolute numbers than the Northeast, one of the poorest regions in the country, during the period evaluated. This may be related to the fact that liver transplants are high-risk and high-cost procedures that require strong health structures[9], which suggests that the observed differences between these two regions may be due to economic and social factors.

The national registry for liver and other organ transplants is a single registry. However, the distribution of organs donated due to brain death is, initially, state and, later, within macro-regions established in Ordinance No. 2,600 of the Ministry of Health, of October 21, 2009[9]. This fact may contribute to the maintenance of disparities in liver transplantation in Brazil, given the imbalance between the demand and availability of viable organs in different Brazilian locations[10].

Faced with the reality presented, due to the inequality in the distribution of digestive tract surgeons in Brazil and the lack of structure to perform liver transplant surgeries in many states and regions, the time between the diagnosis of the need to perform a transplant and the execution of the event becomes very broad, given the need to travel to another state or region to perform the

Table 2. Distribution of Digestive Tract Surgeons by Federation Unit.

Region/ State	Digestive tract surgeons	Population	Per 100 000 inhabitants
North Region	158	18 906 962	0.84
Acre	07	906.876	0.77
Amapá	02	877.613	0.23
Amazonas	30	4.269.995	0.70
Pará	80	8.777.124	0.91
Rondônia	16	1.815.278	0.88
Roraima	03	652.713	0.46
Tocantins	20	1.607.363	1.24
Northeast Region	456	57 667 842	0.79
Alagoas	19	3.365.351	0.56
Bahia	109	14.985.284	0.72
Ceará	56	9.240.580	0.61
Maranhão	44	7.153.262	0.62
Paraíba	41	4.059.905	1.00
Pernambuco	97	9.674.793	1.00
Piauí	33	3.289.290	1.00
Rio Grande do Norte	32	3.560.903	0.90
Sergipe	25	2.338.474	1.07
Midwest region	350	16 707 336	2.09
Distrito Federal	88	3.094.325	2.84
Goiás	158	7.206.589	2.19
Mato Grosso	56	3.567.234	1.56
Mato Grosso do Sul	48	2.839.188	1.69
Southeast Region	2030	89 632 912	2.26
Espírito Santo	67	4.108.508	1.63
Minas Gerais	257	21.411.923	1.20
Rio de Janeiro	100	17.463.349	0.57
São Paulo	1606	46.649.132	3.44
South Region	846	30 402 587	2.78
Paraná	382	11.597.484	3.29
Rio Grande do Sul	258	11.466.630	2.25
Santa Catarina	206	7.338.473	2.80
Total	3840	213.317.639	1.80

Source: Brazilian Federal Council of Medicine, 2022.

transplant surgery[11] , In this context, patients using the Unified Health System often need to travel interstate or inter regionally to be able to undergo a mortality-modifying surgery (Table 1). With this, patients who often have limited financial conditions, need to pay for the displacement to another state and their stay and that of the companion for as long as necessary[12].

Over and above that, considering that the medical team responsible for diagnosing and delineating the course of treatment to be followed differs from the team that will perform the surgery, often requiring new tests and pre-and postoperative consultations, which increase the patient's length of stay in another state, and therefore the financial cost to the patient themself[13]. It is known that there is aneed for studies focused on evaluating these costs to clarify the financial impact on the disparity of liver transplantation.

Limitations

This article is limited, particularly with regard to the lack of demographic data through DATASUS. It is also known that due to the data on transplants only being updated until April 2022, this may configure a notification bias and the subsequent distortion of data due to under-notification or notification error, which is more common in the North and Northeast regions of Brazil than in other regions[13], but that it was mitigated through statistical calculations, the system through which we accessed the data is open for research by any individual and is constantly updated. It is important that more studies related to transplant disparities in Brazil are necessary, including to evaluate the level of representation of these surgeries during 2020 due to the COVID-19 pandemic.

Despite the limitations, the provided data to be important. Access and the number of surgeons associated with liver transplants have been described in this country for the first time, and the findings of this study have significant implications for improving the overall public health system.

CONCLUSION

Based on what has been exposed, it is evident that in Brazil, the universality of performing liver transplants among the Regions of the country is still a substantial challenge. The sizeable territorial extension, and the lack of professional and structural technical capacity in hospitals, resulted in a large concentration of transplants in main regions, such as the south and southeast, while other states, even with demand, cannot be attended to in their region of origin.

Brazil should enhance its organ transplantation outcome measurement system to obtain more comprehensive and comparable data for international comparisons. Current estimates using standard ratios overlook regional differences in disease burden. Improved epidemiological data collection can inform health service planners, and public disclosure of healthcare spending on sub-services is vital for scholarly evaluations. Addressing the historical mismatch of healthcare funding with disease burden in Brazil is crucial[14,15].

Increasing public trust in health services through awareness campaigns and early donation request training during undergraduate education could benefit the transplantation system.

Additionally, there is an opportunity for Brazil to innovate by regionalizing transplantation services, especially in pre- and postoperative follow-up assessments. Some departments are already pioneering telehealth projects to provide specialized healthcare to remote areas[15].

For all to receive safe, cost-effective, and timely liver transplant and prevent your geographical location from being a barrier to your access to healthcare. It is crucial that surgical procedures are a central component of both global and national transplant plans.

CONFLICT OF INTEREST

Nothing to declare.

AUTHOR'S CONTRIBUTION

Substantive scientific and intellectual contributions to the study: Vieira LVS, Reis JF, Leitão EL, França BNA, Gomes MBV, Salvador SD, Silva ROS; **Conception and design:** Vieira LVS; **Data analysis and interpretation:** Vieira LVS, Leitão EL, Salvador SD; **Article writing:** Vieira LVS, Reis JF, Leitão EL, Gomes MBV, Salvador SD; **Critical revision:** Vieira LVS, Reis JF, Leitão EL, Gomes MBV, Salvador SD; **Final approval:** Vieira LVS, Reis JF, Leitão EL, França BNA, Gomes MBV, Salvador SD, Silva ROS.

DATA AVAILABILITY STATEMENT

The data is available upon request.

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No applicable.

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