Frequency of splenectomy for pediatric splenic injury in Brazil: a retrospective analysis

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Summary

Background Non-operative management for pediatric blunt splenic injury is well established in high-income countries, leading to a low splenectomy rate in hemodynamically stable children. Splenectomy rate became a quality indicator for Trauma Center verification utilized by the American College of Surgeons Committee on Trauma. However, data on splenectomy rate in children from countries with different income levels, such as Brazil, remain limited. This study aimed to assess the post-traumatic splenectomy rate among Brazilian children over the past decade and the relation with local resources.

Methods Data on pediatric splenic injuries and splenectomies from 2008 to 2019, including patient age and admitting service (adult or pediatric), were obtained from FioCruz database, a public, free, cloud-based platform that offers extensive national health data. The regional numbers of pediatric surgeons, pediatric intensive care unit (PICU) beds, and computed tomography scanners were obtained from Brazilian national databases. A national analysis of splenectomy rate by year and service of admission and an analysis of splenectomy rate by the level of regional resources, the number of pediatric surgeons, PICU beds, and computed tomography scanners was performed.

Findings 4061 children were hospitalized with a splenic injury, and 2287 (51.8%) of them underwent splenectomy, unchanged over time. 76.8% were male and 23.1% female patients with splenic injury. Mean age was 11.61 years old. The odds of splenectomy was 14.77 times higher for pediatric patients admitted under adult surgical service compared to pediatric service (OR = 14.77, 95% CI 11.75–18.56, $p < 0.0001$). The overall increase in pediatric surgeons, PICU beds, and CT scanner availability did not correspond with changes in splenectomy rate.

Interpretation The post-traumatic splenectomy rate among Brazilian children is high, far exceeding that of high-income countries. Increased regional pediatric resources did not correspond to a decrease in splenectomy rate. Further research is essential to understand Brazil's barriers to adopting non-operative management for pediatric splenic injuries.

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Keywords: Spleen; Trauma; Pediatric; Non-operative; Conservative; Surgery; Global health; Brazil

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Research in context

Evidence before this study

We searched PubMed, BVS, Embase, Scopus, and Web of Science for studies on the management of abdominal solid organ injuries in children. We used the search terms: ("abdominal injury" OR "splenic injury" OR "abdominal trauma" OR "spleen AND injury") AND ("children" OR "child" OR "infant" OR "infantile"). Our search was restricted to articles that either dealt exclusively with children under 18 years of age or dealt with adults and children, while considering the children separately. The search was limited to studies published before November 1, 2023, and included studies in English, Spanish and Portuguese language, yielding 3779 studies. From our search, only four articles from Brazil were identified. The most recent Brazilian article was published in 2016, marking an eight-year gap from the previous study. Of these, only one article provided quantitative data on pediatric patients with solid organ injuries, describing three cases. Despite substantial evidence supporting non-operative management for pediatric splenic injury in High-Income Countries (HIC's), research concerning pediatric splenic injury management across different economic settings is limited. Particularly in Brazil, classified as an upper-middle-income country, the rates of post-traumatic pediatric splenectomy have yet to be quantified, highlighting a significant gap in the existing literature.

Added value of this study

This study presents a novel and comprehensive analysis of the management of pediatric splenic injuries within Brazil, a country with varied socioeconomic and healthcare resources. We identified a rate of splenectomies for splenic injury among Brazilian children ten times higher than that observed among children in high income countries over the past decade. This discrepancy persists despite an overall increase in the Brazilian pediatric surgical workforce, and increased availability of computed tomography (CT) scanners and pediatric intensive care unit (PICU) beds.

Implications of all the available evidence

Our findings demonstrate a marked difference in the management of pediatric splenic injury in Brazil compared to high-income countries. This discrepancy has broad implications for pediatric trauma care in Low- and Middle-Income Countries (LMICs) and raises questions about the etiology of this disparity. Factors beyond resource availability, such as entrenched clinical decision-making practices and a lack of familiarity with non-operative management for pediatric splenic injury care may contribute to this issue. Our data underscore the need for the broad dissemination of information regarding trauma care practices and enhanced training in pediatric injury care in Low- and Middle-Income Countries.

Introduction

The safety and effectiveness of non-operative management for blunt splenic injury in hemodynamically stable children has been well-documented in high-income countries (HICs), solidifying it as the standard treatment for more than two decades.[1–3] Non-operative management reduces hospital costs and patient complications, decreasing length of stay, the need for transfusions, and the risk of post-splenectomy infection.[4] Guidelines from the American Pediatric Surgical Association recommend non-operative management as it has been shown to reduce splenectomy rates.[5] In HICs, non-operative management has led to approximately a 5% post-traumatic splenectomy rate, and successful splenic salvage is used as a quality indicator in pediatric trauma.[4,6] Interestingly, Bowman and Hamlat revealed variability in splenectomy rates for pediatric splenic injuries depending on whether patients are managed by pediatric surgeons or adult surgeons.[7,8] However, these findings and the knowledge regarding non-operative management stem from HICs, with limited research on post-traumatic splenectomy rates in children from other income settings.[9,10]

A disproportionate burden of pediatric trauma occurs in low-income countries and low-middle-income countries (LMICs), contributing to preventable morbidity and mortality. Pediatric trauma care in these countries is often provided at general hospitals, where injured children may lack access to well-prepared trauma teams.[11] Brazil, an upper middle-income country, follows this pattern, and pediatric trauma remains a neglected disease in the country.[11] Until now, no previous studies have investigated post-traumatic splenectomy rate in Brazilian children, despite its correlation with the quality of care in pediatric trauma.[6]

The global significance of examining Brazilian post-traumatic splenectomy rate relies on some of the country's unique characteristics. Brazil was one of the first countries to institute universal health coverage, serving as a model for other nations seeking to establish more equitable health systems.[12] In 2020, Brazil also achieved a substantial pediatric surgical workforce comprising 1514 pediatric surgeons (3.4/100,000 children under 15 years old).[13] However, the imbalanced distribution of this surgical workforce between Brazilian regions presents an obstacle to the provision of adequate pediatric trauma care.[14] Brazil's poorest regions have the same ratio of pediatric surgeons per 100,000 children as low-income countries and LMICs, in contrast to the wealthier regions, which approach the pediatric surgical

workforce levels seen in HICs.[13,15] Thus, identifying trends and discerning disparities in the management of pediatric splenic injuries in various Brazilian regions holds the potential not only to inform resource allocation and policymaking within Brazil but also to other regions of the world with similar characteristics and challenges.

This study's primary objective is to evaluate the post-traumatic splenectomy rates among Brazilian children over the last decade. Moreover, we sought to investigate variations in splenectomy rates between pediatric and adult surgical services and to explore potential relation with the number of pediatric surgeons, pediatric intensive care unit (PICU) beds, and computed tomography (CT) scanners by region. By gaining a granular understanding of Brazilian pediatric trauma care related to splenectomy rate, we aspire to provide insights for developing both local and global interventions to enhance pediatric trauma care.

Methods

Study design

This cross-sectional study evaluated the national annual rates of splenic trauma for children under age 17 in Brazil. Data was retrieved from January 2008 to December 2019. We did not include the years 2020–2022 due to the impact of COVID-19 on the Brazilian healthcare system since the pandemic led to substantial disruptions in elective and urgent surgical procedures, changing surgical practices and creating a backlog of over a million surgical procedures for the following years.[16] The present study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines.[17]

The platform

Data was sourced from the Fiocruz database. The Data Science Platform for Health (Plataforma de Ciência de Dados aplicada à Saúde, PCDaS) is an initiative by the Health Information Laboratory (Laboratório de Informação em Saúde, Lis) of the Institute for Scientific and Technological Communication and Information in Health (Instituto de Comunicação e Informação Científica e Tecnológica em Saúde, Icict) at the Oswaldo Cruz Foundation (Fundação Oswaldo Cruz, Fiocruz), in collaboration with the National Laboratory for Scientific Computing (Laboratório Nacional de Computação Científica, LNCC). The primary goal of PCDaS is to provide technological services and scientific computing for storing, managing, and analyzing large data volumes to researchers, faculty, and students from educational and research institutions. PCDaS is a public, free, cloud-based platform that offers extensive microdata and analytical tools for health research. It provides anonymized patient data to all basic and academic users.

The microdata, extracted from various sources and integrated for analysis, includes data from the Information Technology Department of the Public Health Care System (SUS), also known as the SUS-SIH databases. Managed by the Department of Informatics of the Unified Health System through the DATASUS program, these databases maintain a comprehensive repository of health data collected from public hospitals across Brazil. This includes patient demographics, hospital admissions, procedures performed, and outcomes, all inputted by healthcare professionals. Although the implementation of this information system is not universal, all hospitals affiliated with the Unified Health System (Sistema Único de Saúde, SUS) have access to the Hospital Information System (Sistema de Informações Hospitalares, SIH), which serves as a complementary information source to support epidemiological surveillance efforts. When these data are made available in open databases, they do not contain any information that could identify patients. The data are solely for epidemiological surveillance, aimed at increasing the system's dissemination among epidemiology professionals, highlighting its limitations and possibilities. Despite the SIH's limitations for surveillance use, its systematic and critical exploration leads to continuous improvement of its information as it suggests adjustments to the system, such as aligning performed procedures with diagnoses, issuing notification forms at the time of hospital admission authorization, and adjusting the procedure schedule for notifiable diseases, encouraging investigative actions, among other recent enhancements.

Participants

We accessed the "*Sistema de Informações Hospitalares do SUS*" (Hospitalar Information of the Brazilian Public Health System) in chapter XIX of this platform. We collected data using the International Classification of Diseases (ICD-10) codes for Intra-Abdominal trauma (S36) and Splenic Trauma (S36.0). The national annual estimates collected were spleen trauma and splenectomies performed in children ages 0–17 years. The classification of the type of bed each hospitalized child occupied followed the categories offered by *PCDaS*. Only variables without missing data were collected for this analysis.

The study size was determined by including all available *PCDaS* data that met the cited conditions. Therefore, no sampling process was performed, ensuring a comprehensive analysis of the available data.

Procedures

The primary outcome assessed was the splenectomy rate. We obtained data from *PCDaS* on splenectomy and spleen trauma incidence by patient age, year of admission, type of surgical service the patient was admitted to (pediatric versus adult), and region in Brazil. We

excluded children who were admitted to a general clinical service under the assumption that they did not receive a surgical evaluation.

- The secondary outcome was to investigate the relationship between the pediatric post-trauma splenectomy rate and pediatric specialty resources, including pediatric surgeons, PICU beds, and CT scanners. The number of PICUs from 2020 was retrieved from Brazil's Public Health System Informatics Department, *Cadastro Nacional de Estabelecimentos de Saúde/National Register of Healthcare Facilities,* known as the DATASUS platform. CT scanners per region from 2012 to 2019 were also collected from DATASUS. The number of pediatric surgeons per state from 2019 was obtained from the *Demografia Médica* 2020,[13] a National Medical census promoted by the *Associação Médica Brasileira, Fundação Faculdade de Medicina,* and the University of São Paulo. *Demografia Médica* reports Brazil's geographical distribution and availability of human healthcare resources.

Statistical analysis

Categorical data were described by frequencies and percentages, and univariate analysis was made using the chi-square or Fisher's exact test whenever appropriate. The strength of the association between the splenectomy rate and the type of facility of admission was estimated by the Odds Ratio (OR), using the Baptista-Pike Method. Simple linear regression (using the year of occurrence as a dependent variable and the number of admissions and the splenectomy rates as separate independent variables) was used to investigate trends of splenectomy admissions and rates over the years. To investigate if the slope of the regression line differed significantly from zero an F statistic was used. Double-sided p-values <0.05 were considered statistically significant. Analyses were performed using Stata Statistical Software (StataCorp LLC, Texas, USA) and GraphPad Prism 10.0 (GraphPad Software, California, USA).

Role of the funding source

All authors had full access to all the data and accepted responsibility to submit for publication. There was no sponsor or funding for this research.

Ethical approval

Ethical approval was not required for this project as all data were collected from publicly available databases, ensuring that no patient identification was involved. The data used were already anonymized and contained no personally identifiable information, thus conforming to ethical guidelines for public domain data usage and ensuring no risk to individual privacy.

Results

Overall results

A total of 4412 children were hospitalized for splenic injuries between January 2008 and December 2019. There were 1020 girls and 3392 boys. Mean age was 11.61 years old. Approximately half of these children underwent a splenectomy [2287, 51.8%, 95% Confidence Interval (95% CI) (50.35–53.32)], with no difference regarding gender (Table 1). The distribution of the splenectomy rate by age group is depicted in Table 2 and Fig. 1. These data show that the splenectomy rate tended to be higher in older children (chi-square = 66.8518, $p < 0.0001$).

Splenectomy rate by service of admission and by age

Of 4412 hospitalized children, 74.45% (3285) were admitted to adult surgical services, and 17.58% (776) were admitted to pediatric services. The remaining 7.95% (351) of children were admitted to a general clinical service and were therefore not included in the subanalysis. Among the 4061 patients admitted to either a pediatric or adult surgical services, the splenectomy rate was significantly lower among patients admitted to a pediatric service (93/776, 11.9%) compared to those admitted to an adult surgical services (2194/3285, 66.7%). The odds of splenectomy was 14.77 times higher for pediatric patients admitted under adult surgery compared to pediatric services (OR = 14.77, 95% CI 11.75–18.56, $p < 0.0001$). This tendency was observed in all age groups, but there was a linear trend in the strength of the association. It continually decreased from younger to older children ($p < 0.0001$) (Table 3 and Fig. 2).

Pediatric injuries overtime

The rate of admission to adult services for splenic injury in patients aged 16 and under decreased significantly from 2008 to 2019 (Fig. 3); however, annual splenectomy rates remained stable over the study period. The number of admissions for splenic injury to pediatric services remained stable over the study period, ranging from 52 occurrences in 2016 to 80 occurrences in 2015. The median number of occurrences was 63.5 (Interquartile Interval 50–77). The comparative analysis for the distribution of data over the years showed a significant reduction in the admissions performed in adult services from 2008 to 2019 ($p = 0.0037$). The admissions performed in pediatric services in the same period remained stable ($p = 0.2180$) (Fig. 3).

Splenectomy rate by CT availability

The availability of CT scanners increased across all regions of Brazil from 2012 to 2019. The Midwestern region (91.3%) had the most substantial rise, followed by North (80.5%), Northeast (72.4%), South (57.1%) and Southeast (49.3%) regions.

Gender	Admissions	Splenectomy	Splenectomy rate	95% CI
Male	3392 (76.88)	1792 (78.35)	52.8%	0.51–0.54
Female	1020 (23.12)	495 (21.65)	48.5%	0.45–0.51
Total (%)	4412 (100)	2287 (100)	51.8%	0.50–0.53

Table 1: **Distribution of admissions for spleen trauma and splenectomy rate by age in Brazil from 2008 to 2019.**

Age	Admissions	Splenectomy	Splenectomy rate	95% CI
0–5 years	357 (8.09)	135 (5.90)	37.8%	0.32–0.43
6–10 years	1023 (23.18)	465 (20.33)	45.45%	0.42–0.48
11–15 years	1675 (37.96)	903 (39.48)	53.91%	0.51–0.56
16–17 years	1357 (30.75)	784 (34.29)	57.77%	0.55–0.60
Total	4412 (100)	2287 (100)	51.8%	0.50–0.53

Chi-squared analysis showed a significant difference in the rate of splenectomy among the different age groups. (chi-squared: 66.8518; $p < 0.0001$).

Table 2: **Distribution of splenectomy rates by age group.**

Splenectomy rate by PICU bed availability

The number of PICU beds increased across all regions from 2012 to 2019. The most substantial rise was observed in the Midwestern region (71.58%), followed by Northeast (48.71%), Southeast (27.16%) and North (25.85%) regions. The lowest increase was found in the Southern region (8.63%).

Splenectomy rate by geographical region and pediatric surgeon distribution

The mean splenectomy rate in each geographical region of Brazil over the past decade was 68.14% in the North, 58.84% in the Northeast, 51.76% in the Midwest, 46.85% in the Southeast, and 43.29% in the South. The presented results are expressed as a relative value, calculated by considering the population of each region individually. This approach was adopted to address any potential bias that could arise from regions with larger populations.

In 2020, the number of Pediatric Surgeons in Brazil was 1514 (3.4/100,000 children). The Northern region had the lowest number, with 65 professionals (4.3%), Northeastern region had 254 (16.8%), and Midwestern region had 139 (9.2%) pediatric surgeons, while the Southeastern and Southern regions had 796 (52.6%) and 259 (17.1%), respectively. According to DATASUS, there has been a noteworthy national increase of 47.71% in their workforce during the period from 2012 to 2019. However, this growth has been heterogeneous across different geographical regions in this period. Notably, the Northeast, Southeast, and South regions exhibited significant increases of 55.88%, 25.58%, and 343.75%, respectively. The mean splenectomy rate in each geographical region of Brazil is depicted in Table 4 and in Figs. 4 and 5. The North and Midwest regions experienced a decline in the workforce of pediatric surgeons, with reductions of –4.77% and –6.78%, respectively, also with stable splenectomy rate. Despite the changes in the number of pediatric surgeons in all regions, the annual splenectomy rates remained stable over the study period. Visual analysis of the data shows that, although the splenectomy rates were higher in the North and Northeast regions of Brazil, this trend does not appear to have any consistent relationship with the quality of access to health facilities or professionals.

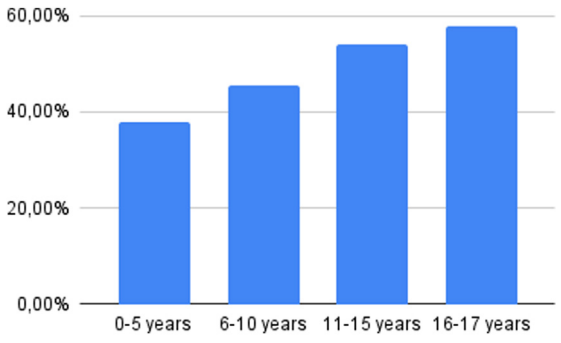

Fig. 1: Graphic representation of the distribution of the splenectomy rate by age group.

Discussion

Our study identified a remarkably high splenectomy rate among Brazilian children hospitalized due to splenic injuries. The splenectomy rate remained stable throughout the ten-year period of the study despite the overall increase in the pediatric surgical workforce, PICU bed, and CT scanner availability. Overall, 51.8% (2287/4412) of the children underwent splenectomy, with most of these procedures performed in children admitted to adult surgical services. Pediatric patients admitted to adult surgical services faced a 14.77 times higher odds of splenectomy when compared to those

Age group (years)	Admissions to a pediatric service			Admissions to an adult service			Statistics (Pediatric versus adult service admissions)		
	Admissions	Splenectomy	Rate (95% CI)	Admissions	Splenectomy	Rate (95% CI)	Chi- square	p	OR (95% CI)
0–5	108	5	4.63% (0.01–0.10)	209	130	62.20% (0.55–0.68)	94.18	<0.001	33.89 (13.24–86.78)
6–10	305	31	10.16% (0.07–0.14)	625	434	69.44% (0.65–0.73)	288.08	<0.001	20.08 (13.35–30.22)
11–15	308	38	12.34% (0.08–0.16)	1.251	865	69.14% (0.66–0.71)	324.91	<0.001	15.92 (11.11–22.83)
16–17	55	19	34.55% (0.22–0.48)	1.200	765	63.75% (0.60–0.66)	17.91	<0.001	3.33 (1.88–5.88)
TOTAL	776	93	11.98% (0.09–0.14)	3.285	2.194	66.79% (0.65–0.68)	766.36	<0.001	14.77 (11.75–18.56)

CI, Confidence Interval. The Chi-square test was used for age group comparison, and odds ratios (OR) were estimated to present the odds of children having splenectomy by adult surgical services compared to pediatric surgical services. In all age groups, the odds of children being admitted to adult surgical services were significantly higher than the odds of being admitted to pediatric surgical services.

Table 3: **Distribution of splenectomy rates by service.**

admitted to pediatric services. Notably, children aged zero to five exhibited the most significant disparity in splenectomy rate between the services of admission.

Similar trends are observed in HICs, where children with splenic injuries are more likely to receive operative management, specifically splenectomy, in adult surgical services than in pediatric ones.[18–21] A study in a HIC reported a 12.7% splenectomy rate in adult trauma centers versus 7.8% in specialized pediatric centers, even after adjusting for age and injury severity.[22] Our findings align with these observations, suggesting a consistently higher tendency toward splenectomy in Brazilian children admitted to adult surgical services. However, it is important to clarify that the service of admission in Brazil does not always reflect the care provider; pediatric patients admitted to adult services may still receive care from pediatric surgeons. Nevertheless, the discrepancy observed in the splenectomy rate between the services of admission implies that a relevant portion of these children is likely being treated by adult surgeons, indicating a potential gap in pediatric-specific trauma care expertise in adult settings.

Despite the safety and efficacy of non-operative management for pediatric solid organ injuries, the overall prevalence of post-traumatic splenectomies in Brazil is notably high, tenfold the rate observed in HICs.[4,6] The differences in the management of pediatric spleen trauma between LMICs and HICs may be attributed to a range of factors. The limited size and/or uneven distribution of the pediatric surgical workforce in LMICs and inadequate access to specialized pediatric and critical care services may be significant contributors. The scarcity of diagnostic imaging technologies, such as ultrasound or CT scanners, may also lead to a greater dependence on surgical intervention as both a diagnostic and therapeutic method in LMICs.[9,10] Furthermore, the absence of standardized national guidelines for pediatric spleen trauma management might shape treatment approaches.[23,24] Importantly, pediatric trauma care protocols developed in HICs are not directly transferable to the LMIC context. In the absence of specific local guidelines, surgeons in LMICs might lean towards treatment methods with which they are most familiar or that seem most definitive. In the case of splenic injuries, this often means opting for splenectomies.[22]

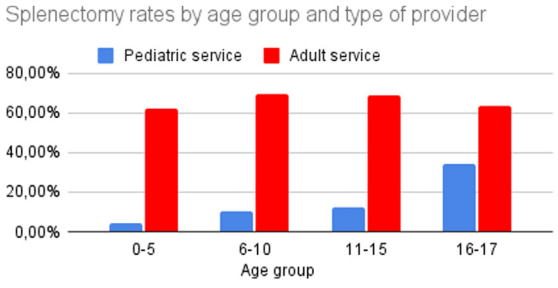

Fig. 2: Graphic representation of the splenectomy rates for adult and pediatric surgery services stratified by age group.

In our study, we used the number of PICU beds and CT scanners available as indicators of healthcare center complexity and resource availability, which are relevant for effective patient management. This approach aimed to investigate the relationship between these resources and the observed splenectomy rate. Despite a significant increase in these resources, especially in the Midwestern region (CT scanners at 91.29% and PICU beds at 71.58%), we observed no corresponding change in splenectomy rates. Contrary to our initial hypothesis, the enhancement in healthcare resources did not translate into a reduction in splenectomy rates. The reasons for this might be multifaceted, including the possibility that other factors, beyond resource availability, may be critical to influence surgical decision-making, such as surgical expertise, familiarity with pediatric non-operative management protocols, and local practice patterns.

Geographically, the splenectomy rates varied significantly across regions, with the highest rates observed in the North and the lowest in the South. This variation aligns with Brazil's well-documented socioeconomic regional disparities. These disparities translate into differences in healthcare infrastructure and the availability

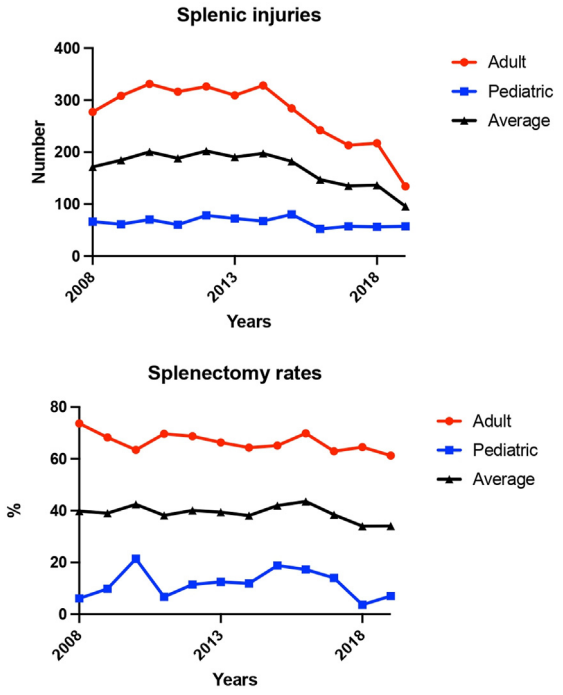

Fig. 3: Graphic representation of the yearly evolution of the number of admissions for splenic injury from 2008 to 2019 in adult and pediatric service. Simple linear regression disclosed a significant reduction, over the years, in the number of children admitted to adult wards for splenic injury (F = 14.17, p = 0.0037), and in the splenectomy rate of children admitted to an adult service (F7.456, p = 0.0212).

of pediatric surgeons. Interestingly, despite an overall increase in the pediatric surgical workforce over the years, Brazil has not observed a corresponding decrease in overall splenectomy rates. Even in economically affluent regions like the South and Southeast, splenectomy rates remain high at 43.30% ± 10.4% and 46.8% ± 6.8%, respectively, despite also the reduction in pediatric spleen trauma cases. This trend suggests that the high splenectomy rates issue extends also beyond workforce availability.

Several factors may contribute to the persistently high rates of splenectomies, even in resource-rich areas. These include the high volume of cases, encompassing both adult and pediatric patients, managed through the referral system.[1] The system may lead to over-triage, directing all trauma cases to trauma centers, which could influence the decision-making process in favor of surgical interventions and increase staff burnout.[25] Additionally, the absence of a dedicated pediatric trauma leader and gaps in pediatric trauma knowledge may also be critical concerns.[11] Furthermore, in Brazil, the organization of pediatric surgical teams within hospitals adds a unique imperative in this context. Most hospitals in the country, especially in the poorer regions, do not have a dedicated pediatric surgical team; instead, they rely upon several on-call pediatric surgeons. These surgeons often hold multiple jobs and are constantly on call at various hospitals.[26] This multi-hospital, on-call system poses a significant challenge to the practice of non-operative management, which requires consistent and daily monitoring of the patient's condition. Consequently, Brazilian pediatric surgeons, balancing various responsibilities, may opt for operative treatment, such as splenectomy, to ensure patient safety rather than continuous monitoring, which is less feasible in their work context.

Another possible explanation for our findings is the limited use of angioembolization for treating post-traumatic injuries in Brazil. The availability of this technique is restricted even among adults, with no published data identified on its use for treating post-traumatic splenic injuries in children.[27] This lack of access could be one of the factors contributing to the observed higher rates of splenectomy in the Brazilian pediatric population. However, while interventional radiology has been effectively employed in adults for splenic salvage, its impact in pediatric cases remains less substantiated by evidence.[28–30]

Despite the various possible contributors to the high splenectomy rate among post-traumatic Brazilian children, a key strategy for enhancing pediatric trauma outcomes is pediatric trauma care training.[31] Systematic trauma care can potentially decrease mortality rates by 15–20%.[32] Notably, the efficacy of trauma training, such as the Advanced Trauma Life Support (ATLS) course, often surpasses the impact of injury severity on

Analysis by country region

Regions of Brazil	Admissions	Splenectomy	Rate (95% CI)	CT 100.000hab	PICU 100.000hab	PedSurg 100.000hab
North	474	323	68,14% (0.63–0.72)	1.820	2.71	1.29
Northeast	1013	596	58.84% (0.55–0.61)	1.627	2.25	0.18
Midwest	425	220	51.76% (0.46–0.56)	3.501	4.44	0.31
Southeast	1851	867	46.84% (0.44–0.49)	8.388	11.11	1.05
South	649	281	43.30% (90.39–0.470)	1.029	0.85	0.16

CI, Confidence Interval; CT, Computed Tomography; PICU, Pediatric Intensive Care Unit; PedSurg, Pediatric Surgery.

Table 4: **Distribution of the splenectomy rates by the different regions of Brazil and its relation to the different indicators of access to health services.**

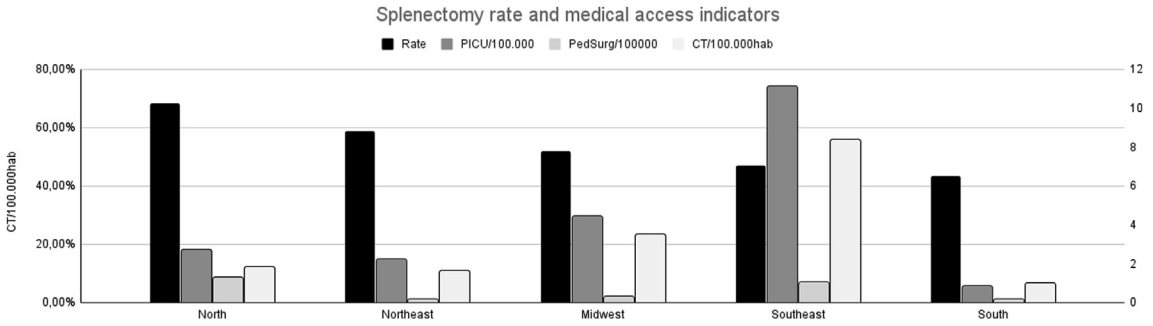

Fig. 4: Graphic representation of the distribution of the splenectomy rates by the different regions of Brazil and its relation to the different indicators of access to health services. Visual analysis of the data shows that, although the splenectomy rates were higher in the North and NorthEastern regions of Brazil, this trend does not appear to have any consistent relationship with the access to health facilities or professionals.

treatment outcomes, benefiting patients across all age groups.[33] However, the effectiveness of general trauma training for pediatric trauma management is less straightforward.[31] This is due to the unique anatomical and physiological characteristics of children and the often-limited confidence among healthcare providers in handling pediatric trauma.[31]

In Brazil and other LMICs, adult surgeons predominantly administer pediatric trauma care in adult facilities, most of whom lack specialized training in pediatric trauma.[11,34] For instance, a survey in a Brazilian trauma center showed that 85.7% of clinicians reported feeling unqualified to treat pediatric patients, underscoring the need for specialized surgical training in this field.[14] In LMICs, the situation is exacerbated by a lack of financing support for staff training.[11,34] Additionally, the limited educational interventions in pediatric trauma available often prioritize pediatric emergency care over trauma and rely on passive teaching methods that lack hands-on experiences or simulations.[14,35,36] To provide better care for pediatric trauma patients, it is imperative to establish dedicated pediatric trauma teams and provide financial support for specialized training.[34]

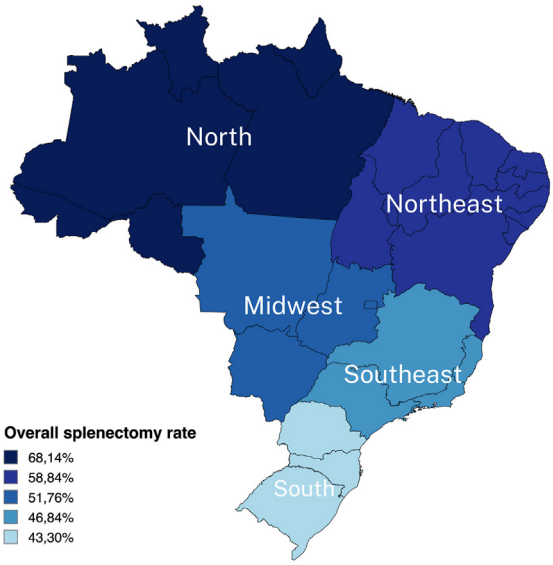

Fig. 5: Overall splenectomy rate per 100,000 population by geographical region in Brazil in 2019.

Our study serves as a starting point for identifying deficiencies in pediatric trauma care provision in Brazil since successful splenic salvage can be used as a quality indicator in pediatric trauma.[4,6] Several strategies can be implemented to improve the quality of pediatric trauma care and reduce splenectomy rates. Optimizing triage protocols could reduce the admission of minor trauma cases in referral centers. Additionally, appointing pediatric trauma leaders for each shift and providing ongoing medical education on the regional differences in pediatric trauma epidemiology and hospital resource availability are crucial.[11]

Training is a critical yet underutilized tool in enhancing pediatric trauma care in LMICs.[31] Despite the significant burden of pediatric trauma in these regions and the pivotal role of education in addressing it, a recent review identified a surprisingly small number of pediatric trauma training courses. Moving forward, the development of standardized pediatric trauma courses tailored to the specific contexts of LMICs is imperative. Such courses should have clear learning objectives focused on pediatric trauma, encompassing technical and non-technical skills. They should be immersive, cost-effective, and include validated assessment tools to ensure their efficacy.[31]

Our study has limitations. First, the reliance on the database, which depends on individual hospitals for data entry, raises the possibility of incomplete data. Moreover, the exact number of trauma centers contributing data to the registry is not publicly available. However, the majority of Brazilian trauma centers are integrated with the public health system, and for these institutions, reporting to the registry is compulsory to secure

funding. Therefore, our study data can be considered a representative sample of most Brazilian trauma centers. The database, not primarily designed for research, may introduce biases due to its diverse healthcare data focus. Another constraint of this platform, when data was collected, resides in the absence of individual-specific information encompassing prior clinical comorbidities, nutritional status, ethnicity, socioeconomic parameters, and access to CT scanners, which may influence the management of pediatric populations and trauma tendencies.[37] As a result, we could not conduct analyses at the individual level. Due to the same limitations in data availability within the database, we were unable to collect information regarding the mechanism of injury and trauma injury severity scores. Moreover, there is a notable absence of Brazilian literature addressing the prevalence of pediatric spleen trauma mechanisms. Nevertheless, regional evidence indicating that blunt injuries account for 73% of trauma-related injuries among Brazilian adults allows us to infer that a similar pattern probably exists in pediatric cases.[38] Our research calls for hospital-level studies where primary data can be collected from charts to corroborate our findings. Due to a lack of data on providers, the severity of the trauma, the mechanism of injury, and surgical complications, our capacity to ascertain the exact reasons behind the observed trends in splenectomy rates was restricted. Another limitation is that while we have data on the type of service to which patients were admitted, detailed information about the healthcare providers' identities and roles was unavailable. Despite the one-year difference in our data, until 2019 for splenectomy rate and from 2020 for PICUs and pediatric surgical workforce, we considered it adequate for use in our analysis. This decision was based on the observation that while the total number of pediatric surgeons increased during the year period, the relative distribution across different regions remained stable. Similarly, PICU bed distribution did not change considerably during the year. Thus, the 2020 data reflects the distinct healthcare realities of different Brazilian regions in 2019. Lastly, it is important to acknowledge that our results are based on a single country and may not be generalizable to other settings. Nevertheless, the pronounced socioeconomic disparities within Brazil, resembling those found in LIC and LMIC, as well as areas with abundant complexity comparable with HIC, potentially enhance the external validity of our findings.

Conclusion

In Brazil, a significant proportion of children with splenic injuries are subjected to splenectomies, contradicting international guidelines that advocate non-operative management for hemodynamically stable children. Despite advancements in healthcare resources, such as increased availability of PICU beds and CT scanners and growth in the pediatric surgical workforce, splenectomy rates have not decreased and surpassed those in high-income countries by tenfold. The persistently high rate suggests that other critical factors beyond the workforce and healthcare resource availability may influence surgical decision-making practices, such as the lack of familiarity with pediatric non-operative management protocols. In this context, improving pediatric trauma training emerges as a key strategy for reducing unwarranted post-traumatic splenectomies.

Contributors

LT, AG, JF and DM conceived and coordinated the study. LT, AG, JB, DM, designed the study. LT, MDF, and TB acquired the data. LT, MDF, TB, JB, and DM verified the underlying data. LT, MDF, TB, JB, and DM prepared the figures. LT, AG, MC, MDF, TB, AN, RF, JB, FB, DM, and JF wrote the first draft report. LT, AG, and JF did the literature search and wrote the manuscript. All authors critically reviewed the paper and approved the final version. All authors had full access to all the data and accepted responsibility to submit for publication.

Data sharing statement

All data used in these analyses are publicly available from Brazil's Public Health System Informatics Department (DATASUS) and the Fiocruz Database (PCDaS).

Declaration of interests

We declare no competing interests.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.lana.2024.100844.

References

1 Mooney DP, Rothstein DH, Forbes PW. Variation in the management of pediatric splenic injuries in the United States. *J Trauma*. 2006;61:330–333. https://doi.org/10.1097/01.ta.0000226167.44892.1d.

2 McDonald LA, Yanchar NL. Management of pediatric splenic injuries in Canada. *J Pediatr Surg*. 2012;47:473–476. https://doi.org/10.1016/j.jpedsurg.2011.08.009.

3 Wang CC, Gupta A, Stone M, et al. A protocol driven approach to reduce lengths of stay for pediatric blunt liver and spleen injury patients. *J Trauma Acute Care Surg*. 2024. https://doi.org/10.1097/TA.0000000000004259.

4 Hakim IS, Newton C, Schoen MK, Pirrotta EA, Wang NE. Nationwide assessment of factors associated with Nonoperative management of pediatric splenic injury. *Am Surg*. 2018;84:695–702. https://doi.org/10.1177/000313481808400522.

5 Williams RF, Grewal H, Jamshidi R, et al. Updated APSA guidelines for the management of blunt liver and spleen injuries. *J Pediatr Surg*. 2023;58:1411–1418. https://doi.org/10.1016/j.jpedsurg.2023.03.012.

6 Simpson AJ, Rivara FP, Pham TN. Quality care in pediatric trauma. *Int J Crit Illn Inj Sci*. 2012;2:149–155. https://doi.org/10.4103/2229-5151.100893.

7 Bowman SM, Zimmerman FJ, Christakis DA, Sharar SR, Martin DP. Hospital characteristics associated with the management of pediatric splenic injuries. *JAMA*. 2005;294:2611–2617. https://doi.org/10.1001/jama.294.20.2611.

8 Hamlat CA, Arbabi S, Koepsell TD, Maier RV, Jurkovich GJ, Rivara FP. National variation in outcomes and costs for splenic injury and the impact of trauma systems: a population-based cohort study. *Ann Surg*. 2012;255:165–170. https://doi.org/10.1097/SLA.0b013e31823840ca.

9 Ameh EA. Management of paediatric blunt splenic injury in Zaria, Nigeria. *Injury*. 1999;30:399–401. https://doi.org/10.1016/s0020-1383(99)00096-0.

10 Chirdan LB, Uba AF, Yiltok SJ, Ramyil VM. Paediatric blunt abdominal trauma: challenges of management in a developing country. *Eur J Pediatr Surg*. 2007;17:90–95. https://doi.org/10.1055/s-2007-965008.

11 Botelho F, Truché P, Caddell L, et al. Implementation of a checklist to improve pediatric trauma assessment quality in a Brazilian hospital. *Pediatr Surg Int*. 2021;37:1339–1348. https://doi.org/10.1007/s00383-021-04941-y.

12 Gragnolati M, Lindelow M, Couttolenc B. *Twenty years of health system reform in Brazil: an assessment of the Sistema Único de Saúde*. World Bank Publications; 2013. https://ideas.repec.org/b/wbk/wbpubs/15801.html. Accessed September 21, 2021.

13 Scheffer M. *Demografia Médica no Brasil 2020. São Paulo: Departamento de Medicina Preventiva da Faculdade de Medicina da USP*. Conselho Federal de Medicina; 2020:312. https://telessaude.fenasaude.org.br/site/wp-content/uploads/2021/03/DemografiaMedica2020_9DEZ.pdf. Accessed September 29, 2021.

14 Botelho F, Truche P, Mooney DP, et al. Pediatric trauma primary survey performance among surgical and non-surgical pediatric providers in a Brazilian trauma center. *Trauma Surg Acute Care Open*. 2020;5:e000451. https://doi.org/10.1136/tsaco-2020-000451.

15 Bouchard ME, Tian Y, Justiniano J, et al. A critical threshold for global pediatric surgical workforce density. *Pediatr Surg Int*. 2021;37:1303–1309. https://doi.org/10.1007/s00383-021-04939-6.

16 Association between government policy and delays in emergent and elective surgical care during the COVID-19 pandemic in Brazil: a modeling study. *Lancet Reg Health Am*. 2021;3:100056. https://doi.org/10.1016/j.lana.2021.100056.

17 Skrivankova VW, Richmond RC, Woolf BAR, et al. Strengthening the reporting of observational studies in epidemiology using mendelian randomization: the STROBE-MR statement. *JAMA*. 2021;326:1614–1621. https://doi.org/10.1001/jama.2021.18236.

18 Variation in treatment of pediatric spleen injury at trauma centers versus Nontrauma centers: a call for dissemination of American pediatric surgical association benchmarks and guidelines. *J Am Coll Surg*. 2006;202:247–251. https://doi.org/10.1016/j.jamcollsurg.2005.10.012.

19 Stylianos S, Nathens AB. Comparing processes of pediatric trauma care at children's hospitals versus adult hospitals. *J Trauma*. 2007;63:S96–S100. https://doi.org/10.1097/TA.0b013e31815acc42.

20 Ochoa C, Chokshi N, Upperman JS, Jurkovich GJ, Ford HR. Prior studies comparing outcomes from trauma care at children's hospitals versus adult hospitals. *J Trauma*. 2007;63:S87–S91. https://doi.org/10.1097/TA.0b013e31815acc0f.

21 Aoki M, Katsura M, Matsumoto S, Matsushima K. Persistent disparities between trauma center types in the management of children with high-grade blunt splenic injuries. *World J Surg*. 2024;48:568–573. https://doi.org/10.1002/wjs.12072.

22 Polites SF, Zielinski MD, Zarroug AE, Wagie AE, Stylianos S, Habermann EB. Benchmarks for splenectomy in pediatric trauma: how are we doing? *J Pediatr Surg*. 2015;50:339–342. https://doi.org/10.1016/j.jpedsurg.2014.09.001.

23 Peitzman AB, Heil B, Rivera L, et al. Blunt splenic injury in adults: multi-institutional study of the eastern association for the surgery of trauma. *J Trauma*. 2000;49:177–187. https://doi.org/10.1097/00005373-200008000-00002.

24 Meira Júnior JD, Menegozzo CAM, Rocha MC, Utiyama EM. Non-operative management of blunt splenic trauma: evolution, results and controversies. *Rev Col Bras Cir*. 2021;48:e20202777. https://doi.org/10.1590/0100-6991e-20202777.

25 Fick AEA, Raychaudhuri P, Bear J, Roy G, Balogh Z, Kumar R. Factors predicting the need for splenectomy in children with blunt splenic trauma. *ANZ J Surg*. 2011;81:717–719. https://doi.org/10.1111/j.1445-2197.2010.05591.x.

26 de Oliveira ALM. *Brazil: case study on working time organization and its effects in the health services sector*; 2015. https://books.google.com/books/about/Brazil.html?hl=&id=v7rvswEACAAJ. Accessed September 21, 2021.

27 Kleinsorge GHD, Drumond DAF, de Paula FCC, et al. Impacto da introdução da angioembolização para o tratamento não operatório do trauma esplênico contuso grau III e IV no Hospital João XXIII, Belo Horizonte/Brasil. *Rev Assoc Med Minas Gerais*. 2021;31:1–6. https://doi.org/10.5935/2238-3182.20210035.

28 Naiditch JA, Notrica DM, Sayrs LW, et al. The use and timing of angioembolization in pediatric blunt liver and spleen injury. *J Trauma Acute Care Surg*. 2024;96(6):915–920. https://doi.org/10.1097/TA.0000000000004228.

29 Kashiura M, Yada N, Yamakawa K. Interventional radiology versus operative management for splenic injuries: a study protocol for a systematic review and meta-analysis. *BMJ Open*. 2019;9:e028172. https://doi.org/10.1136/bmjopen-2018-028172.

30 Swendiman RA, Goldshore MA, Fenton SJ, Nance ML. Defining the role of angioembolization in pediatric isolated blunt solid organ injury. *J Pediatr Surg*. 2020;55:688–692. https://doi.org/10.1016/j.jpedsurg.2019.04.036.

31 Pinkham L, Botelho F, Khan M, Guadagno E, Poenaru D. Teaching trauma in resource-limited settings: a scoping review of pediatric trauma courses. *World J Surg*. 2022;46:1209–1219. https://doi.org/10.1007/s00268-021-06419-3.

32 Kiragu AW, Dunlop SJ, Wachira BW, Saruni SI, Mwachiro M, Slusher T. Pediatric trauma care in low- and middle-income countries: a brief review of the current state and recommendations for management and a way forward. *Pediatr Crit Care Med*. 2017;6:52–59. https://doi.org/10.1055/s-0036-1584676.

33 Carter EA, Waterhouse LJ, Kovler ML, Fritzeen J, Burd RS. Adherence to ATLS primary and secondary surveys during pediatric trauma resuscitation. *Resuscitation*. 2013;84:66–71. https://doi.org/10.1016/j.resuscitation.2011.10.032.

34 Muenyi CS, Kabagambe SK, Ichinose R, Duron VP, Foretia DA. Establishing pediatric trauma programs in low- and middle-income countries. *Curr Trauma Rep*. 2023;9:56–65. https://doi.org/10.1007/s40719-023-00252-w.

35 McCarthy A, Curtis K, Holland AJA. Paediatric trauma systems and their impact on the health outcomes of severely injured children: an integrative review. *Injury*. 2016;47:574–585. https://doi.org/10.1016/j.injury.2015.12.028.

36 Padilla Rojas LG, López Cervantes RE, Pérez Atanasio JM, Sánchez MM, Gómez Acevedo JM, Kojima KE. Latin America trauma systems-Mexico and Brazil. *OTA Int*. 2019;2:e020. https://doi.org/10.1097/OI9.0000000000000020.

37 Viana SW, Faleiro MD, Mendes ALF, et al. Limitations of using the DATASUS database as a primary source of data in surgical research: a scoping review. *Rev Col Bras Cir*. 2023;50:e20233545. https://doi.org/10.1590/0100-6991e-20233545-en.

38 Trajano AD, Pereira BM, Fraga GP. Epidemiology of in-hospital trauma deaths in a Brazilian university hospital. *BMC Emerg Med*. 2014;14:22. https://doi.org/10.1186/1471-227X-14-22.