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Delivery of essential pediatric congenital surgical care within Brazil's universal health coverage system: a national survey of pediatric surgeons

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ABSTRACT

Objective In this study, we assess the delivery of congenital pediatric surgical care under Brazil's system of universal health coverage and evaluate differences in delivery between public and private sectors.

Methods A cross-sectional national survey of pediatric surgeons in Brazil was conducted. Participants were asked which of 23 interventions identified through the *Disease Control Priorities 3 (Surgical Interventions for Congenital Anomalies)* they perform and to report barriers faced while providing surgical care. Responses were weighted by state and stratified by sector (public vs private).

Results A sample of 352 responses was obtained and weighted to represent 1378 practicing pediatric surgeons registered in Brazil during the survey time. 73% spend the majority of their time working in the public sector ('Sistema Único de Saúde' and Foundation hospitals), and most of them also work in the private sector. Generally, Brazilian pediatric surgeons have the expertise to provide thoracic, abdominal, and urologic procedures. Surgeons working mostly in the public sector were more likely to report a lack of access to essential medications (25% vs 9%, p<0.01) and a lack of access to hospital beds for surgical patients (52% vs 32%, p<0.01).

Conclusions Brazilian pediatric surgeons routinely perform thoracic, abdominal, and urologic surgery. Those working in government-financed hospitals face barriers related to infrastructure, which may impact Brazilians who rely on Brazil's universal health coverage system. Policies that support pediatric surgeons working in the public sector may promote the workforce available to provide congenital pediatric surgical care.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Low/middle-income countries (LMICs) bear a disproportionate burden of congenital conditions when compared with high-income countries. It has been proven that investment in surgical care improves outcomes, reduces death and disability rates, and averts chronic treatment costs.

WHAT THIS STUDY ADDS

⇒ As the adoption of universal health coverage systems continues to grow, understanding how specialized care such as congenital surgical care—a high-impact, complex set of interventions requiring a specialized workforce—is delivered in a large, regionally diverse country such as Brazil will help to guide policies, to improve equity and to optimize outcomes.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The next challenges for promotion of quality pediatric surgical care in Brazil will need to center on incentives to support pediatric surgeons working in the public sector as well as addressing issues involving access, transfer of care to higher-level facilities, and the availability of medications, surgical equipment, and other pediatric subspecialists. Our study suggests that barriers to complex surgical care provision are not the same for all LMICs and should be both country and context specific.

INTRODUCTION

Worldwide, it is estimated that 1.7 billion children do not have access to surgical care.[1] The majority of these children live in low/middle-income countries (LMICs) where access to surgery remains limited, particularly in rural areas.[2 3] Congenital defects are a major cause of mortality and morbidity in children, frequently requiring urgent and high-risk surgical interventions in neonates with many implications throughout their lifetime.[1] LMICs bear a disproportionate burden of these congenital conditions when compared with high-income countries.[4]

It has been proven that investment in surgical care improves outcomes, reduces death and disability rates, and averts chronic

treatment costs.[5] Furthermore, globally, a strong surgical workforce has the potential to save as many as 500 000 lives of children under-5 years annually and significantly reduce the financial burden for pediatric conditions.[6 7] Evaluation of the delivery of pediatric surgery worldwide requires a more thorough understanding of pediatric care delivery in existing health systems.

Both the WHO and the World Bank have advocated for universal health coverage (UHC): a system where all individuals receive the health services they need without suffering financial hardship.[8 9] A number of LMICs have adopted national healthcare systems, national insurance plans, or combinations of these coverage systems in order to adopt the ideals of UHC.[10] Brazil was one of the first countries to adopt UHC into its legislation, and currently, 75% of Brazilians depend on the 'Sistema Unico de Saúde' (SUS), a triparty-financed health system administered by the cities, states, and the national government.[10 11] Brazil's population of 213 million inhabitants—44 million of whom are children (0–14 years)—represents a wide range of geographic regions and socioeconomic groups, including remote areas of the Amazon to highly populated, modern cities in the South.[12 13]

Regional disparities in healthcare delivery and more particularly, pediatric surgical care delivery, have been noted despite a diffuse UHC system.[13 14] Brazil will need to be intentional about healthcare policy decisions in order to mitigate existing geographical and economic disparities. Workforce assessments under UHC may provide a key to understanding the best funding allocation and policy development for addressing these disparities.

Surgical care has been recognized as a core component of UHC, but the delivery of subspecialized care within these models requires specific attention.[15 16] As the adoption of UHC systems continues to grow, understanding how specialized care such as pediatric surgery is delivered will help to guide policies and to optimize outcomes. Assessments of pediatric surgical care across Brazil may help to improve equitable access to surgical care for Brazilian children and to act as a model for other countries aiming to adopt UHC systems. Delivery of congenital surgical care within health systems in LMICs represents a high-impact, complex set of interventions requiring a specialized workforce and thus is an ideal proxy for surgical care within the context of UHC.[4] Therefore, this study aims to assess the delivery of congenital pediatric surgical care under Brazil's UHC system SUS and to evaluate the barriers to and differences between the public and private sectors in the provision of this care.

METHODS

Survey design

A 34-question instrument was designed through an international collaboration involving the Program in Global Surgery and Social Change of Harvard Medical School, Brazilian pediatric surgeons, and the Brazilian Association of Pediatric Surgeons (CIPE). The survey included questions on demographic characteristics, region and state of practice, number of years in practice, hospital type (first-level, second-level, third-level, national children's hospital), sector (public vs private), time distribution of clinical versus administrative duties, congenital operations performed, other details of clinical responsibilities, and finally any identified barriers to pediatric care provision. The survey was developed in Portuguese by native Portuguese-speaking physicians. A pilot survey with eight initial Brazilian surgeons was conducted to evaluate the phrasing of questions, ease of interpretation, and clarity of questions of the survey instrument. Appropriate adjustments were made as indicated by the pilot study findings. See online supplemental appendix 1 for a full final survey instrument translated into English.

Core congenital procedures

In the survey, providers were asked to identify which of the core congenital surgical operations they perform at their same primary hospital according to *Surgical Interventions for Congenital Anomalies,* chapter 8 of *Disease Control Priorities Third Edition (DCP3) Essential Surgery volume.*[17] DCP is a multiyear project funded by international institutions to promote and support the use of economic evaluation for priority settings at both global and national levels. The DCP3 underlines the central importance of surgical care. Its findings demonstrate that many essential surgical services rank among the most cost-effective health interventions. The DCP3 recognizes groups of essential surgical conditions and procedures and care needed to treat these conditions that are cost-effective and feasible for worldwide applicability.[17] The Essential Surgery volume offers general guidelines for treating categories of surgical conditions and further delineates the treatment capacity for these conditions at different hospital levels in an ideal setting. To represent overall pediatric surgical capacity, the DCP3 identified a list of 23 essential procedures/conditions for assessment, which can be performed by different specialties. Therefore, the provider type who provides these items can often vary by country, region, or hospital.[18]

Hospital-level categorization

Respondents were then asked to best categorize the level of the hospital in which they spend the majority of their time working according to the Global Initiative for Children's Surgery (GICS) framework. GICS is a collaborative group of providers, institutions, and allies from both high-resource and low-resource settings who aim to improve access to surgery for all children worldwide. They developed the Optimal Resources for Children's Surgery (OReCS) program to identify and promote standards of care to meet this aim. While DCP3 classified delivery into five categories: population based, community level, health center, first-level hospital, and referral

hospital, the OReCS program further classified the top three levels through the lens of surgical care delivery, focusing specifically on care in LMICs. To differentiate these levels effectively, OReCS defined three levels of surgical care for children:

1. Basic: recognition and treatment of minor surgical conditions that do not require a general anesthetic. Referral of more complex surgical conditions and patients with important comorbidities to higher levels of care.
2. Intermediate: recognition and treatment of the most common emergency and essential childhood surgical conditions that may or may not require a general anesthetic. Referral of more complicated childhood surgical conditions and patients with important comorbidities to a higher level of care.
3. Complex/advanced care: treatment of children's complex surgical conditions. Multidisciplinary and highly specialized care.

OReCS further designed resource templates for provision of optimal services at each care level including details of training and staffing, physical resources, and quality and safety. In comparison with DCP3 (World Bank) and the WHO, the national children's hospital category was added because of the notable impact of this type of facility on pediatric care at both the national and international levels. Survey participants were provided with the following definitions to encompass these basic principles so that they may best differentiate their own primary hospital into either first-level, second-level, third-level, or national children's hospital. Definitions were kept fairly basic to account for the wide variation in nomenclature and characteristics in hospital levels by country and region worldwide.

Hospital-level definitions (see online supplemental appendix 1):

- *First-level hospital*: few specialties, especially clinical, gynecology and obstetrics, pediatrics, and general surgery. There may only be a general practitioner or other health professionals. Limited laboratories for general analysis and there is no specialized pathology service; 50–250 beds.
- *Second-level hospital*: more specialized, with 5–10 medical specialties; 200–800 beds.
- *Third-level hospital*: advanced team, with equipment for cardiology services, intensive care center and image unit, for example, highly specialized services, academic activities in some establishments; 300–1500 beds or more.
- *National children's hospital*: comprehensive pediatric surgical care, especially with a multidisciplinary team that has support for the chronic patient; specialists in all areas, who have advanced skills in surgery and anesthesia; education, training of professionals and research in all specialties in pediatric; development of treatment patterns. It has pediatric wards, outpatient clinics and rooms, neonatal, pediatric intensive beds, and burn unit.

Survey administration

In March 2019, an electronic REDCap survey link was distributed via email to the CIPE listserv. Additionally, the survey was distributed through WhatsApp, Instagram, and a Brazilian pediatric surgeons' Google group. The survey was disseminated and administered in Portuguese. All participants were presented with and asked to accept informed consent in order to participate. The survey was voluntary, and no monetary incentive for participation was offered.

Statistical analysis

To compensate for non-response, survey responses were weighted by state using a reciprocal approach based on the number of pediatric surgeons working in each of the 26 Brazilian states. Survey weights were incorporated into the analysis to ensure that each participating surgeon appropriately represented the correct number of surgeons for the Brazilian pediatric surgeon population. The total number of pediatric surgeons working in each state was obtained from the Brazilian Physician Demographics Study for 2018 and used to guide weighting.[19] Survey data were collected and aggregated through REDCap.[20 21] Statistical analysis was performed in R V.3.6.[22] Weighted analysis was performed using the 'Survey' package.[23] Descriptive statistics via univariable analyses were performed using adjacent Wald χ^2 tests. A two-tailed alpha level of 0.05 was used to determine statistical significance.

RESULTS

Pediatric surgeon training and practice

In Brazil, the journey to becoming a pediatric surgeon is a rigorous and lengthy process, spanning a total of 6 years. This involves 3 years of specialized training in general surgery, followed by another 3 years in pediatric surgery residency. It is worth noting that to practice as a pediatric surgeon in Brazil, it is not mandatory to obtain board certification, as long as the training has been completed at an institution accredited by the Ministry of Education. However, many aspiring pediatric surgeons choose to pursue board certification to enhance their credentials and demonstrate their expertise in the field.

A total of 352 pediatric surgeons responded to the survey representing 25.5% of the national pediatric surgeon workforce of 1378 providers during the time of the survey. The total number of providers is based on the count of pediatric surgeons registered with the National Medical Council, which is responsible for granting permission to practice.[19] Surgeons represented all 26 states of Brazil and the federal district. Of the 352 responses, 7.4% (n=26) were from the midwest, 6.0% (n=21) from the north, 18.7% (n=66) from the northeast, 25.6% (n=90) from the south and 42.3% (n=149) from the southeast. The regional distribution was relatively similar to that published in Demografia Medica in 2018 and 2020 for all pediatric surgeons (table 1).

Table 1 Comparative distribution of pediatric surgeons by region

Region (%)	Demografia Medica 2018	Demografia Medica 2020	Study survey
North	3.9	4.3	6.0
Northeast	15.7	16.8	18.7
South	17.9	17.1	25.6
Southeast	53.3	52.6	42.3
Midwest	9.1	9.2	7.4
Total	100 (n=1378)	100 (n=1514)	100 (n=352)

Demografia Medica data are taken from versions 2018 and 2020.[19 24] The study survey represents 25.5% and 23.2% of the 2018 and 2020 pediatric surgery provider population, respectively.

Most pediatric surgeons (73%) report that they spend the majority of their time working in the public sector vs 27% in the private sector. Regionally, we found no difference in the proportion of pediatric surgeons working *primarily* in the public versus private sector (p=0.30) and the proportion of pediatric surgeons working *exclusively* in the private sector (p=0.35). Due to the extremely low number of surgeons who work exclusively in the public sector, we have not included them in our report. To minimize confounders, we have focused on making comparisons between surgeons who primarily work in the public sector versus those who primarily work in the private sector (table 2).

A total of 5.2% of pediatric surgeons reported working in primary hospitals, 16.7% in secondary hospitals, 57.3% in tertiary hospitals, and 20.6% in national children's hospitals (figure 1). Moreover, 38.5% of pediatric surgeons report operating on adults in addition to children. As of March 2023, the CNES (Cadastro Nacional de Estabelecimentos de Saúde (National System of Healthcare Facilities)) database indicates that there are approximately 544 healthcare facilities with pediatric emergency services and 391 with pediatric intensive care units. While there are no specific data available on the number of centers classified as children's hospitals in Brazil to our knowledge, it is worth noting that not all of these facilities are exclusively dedicated to pediatric care, as some may have mixed units or services. Additionally, it is possible that some pediatric service facilities are not registered with the CNES database. Nevertheless, the CNES database remains a reliable source of information regarding the number of healthcare facilities in Brazil.[24]

Interventions for essential congenital surgical conditions

Over 90% of pediatric surgeons across Brazil perform 11 of the 23 essential congenital surgery procedures included in the DCP3 report. Although some Brazilian pediatric surgeons perform interventions such as cleft lip, hydrocephalus, congenital cardiac anomalies, spina bifida, and clubfoot, Brazilian pediatric surgeons are mostly responsible for thoracic, abdominal, and urologic surgery (figure 2). Surgeons working primarily in private hospitals are more likely to be able to perform tracheoesophageal fistula repairs (91% vs 81%, p=0.01) and less likely to be able to do general anesthesia (8% vs 19%, p<0.01) or blood transfusions themselves (40% vs 60%, p<0.01) compared with surgeons working primarily in public hospitals (table 3).

Interestingly, most surgeons can perform most of the thoracic, abdominal and urologic surgeries, independently of the hospital level and region (table 4).

Barriers to the provision of pediatric surgical care

The most commonly reported barriers in this survey were the lack of surgical equipment (60%), failure of patients to pay for services in private hospitals (57%), barriers to the patient access to surgical services—such as distance, lack of transport (40%), and lack of hospital beds for surgical patients (46%). Pediatric surgeons who work mostly in the public sector reported more barriers to pediatric surgical care. Those surgeons were more likely to report a lack of access to essential medications (25% for public sector surgeons vs 9% for private sector surgeons, p<0.01), lack of hospital beds for surgical patients (52% vs 32%, p<0.01), lower reimbursement (61% vs 47%, p=0.03), and accessibility problems (43% vs 31%, p=0.04) (table 5).

Pediatric surgeons working at first-level hospitals were less likely to report a lack of anesthesia service (p<0.01) than physicians working at other hospital levels. Surgeons at first-level and second-level hospitals were more likely to report a lack of equipment (p=0.02), lack of basic infrastructure (p=0.03), lower reimbursement (p=0.03), and patient access issues (table 6).

Table 2 Public versus private pediatric surgeons by region and hospital type

Region, n (%)	Midwest	North	Northeast	South	Southeast	P value
Surgeons working primarily in public sector	89 (70)	45 (79)	177 (83)	185 (76)	487 (69)	0.30
Surgeons working partially in the private sector	113 (89)	48 (84)	179 (84)	200 (83)	586 (82)	0.84
Surgeons working only in the private sector	39 (31)	12 (21)	35 (17)	57 (24)	217 (30)	0.35

Number (n) is estimated based on sample weights, and percentages are based on weighted proportions. P values calculated using adjacent Wald χ^2 tests.

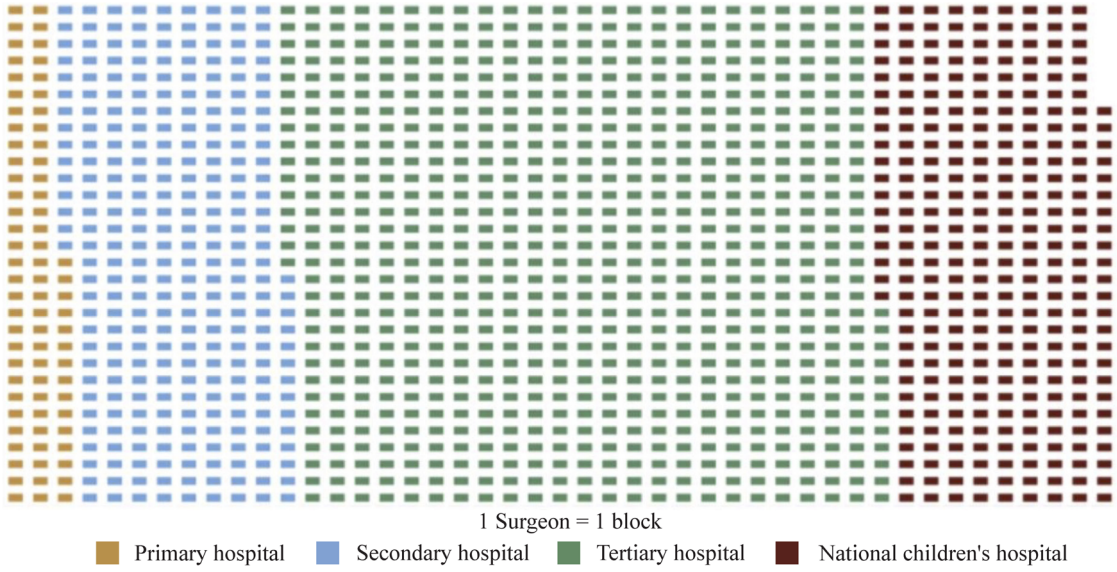

Figure 1 Distribution of Brazilian pediatric surgeons by hospital levels. Responses to the survey were weighted to represent the practice location of each pediatric surgeon across Brazil. While the majority work at tertiary hospitals and national children's centers, there are a considerable number that work at primary and secondary hospitals across Brazil.

DISCUSSION

Our study evaluates essential pediatric congenital care delivery in a country that has implemented a federally funded UHC system. Our results suggest that while there is variation in the individual procedures performed by surgeons, there are very few differences with respect to which procedures are performed in the public versus private sector and even fewer differences in procedures performed among different levels of hospitals. Furthermore, although pediatric surgeons are distributed in

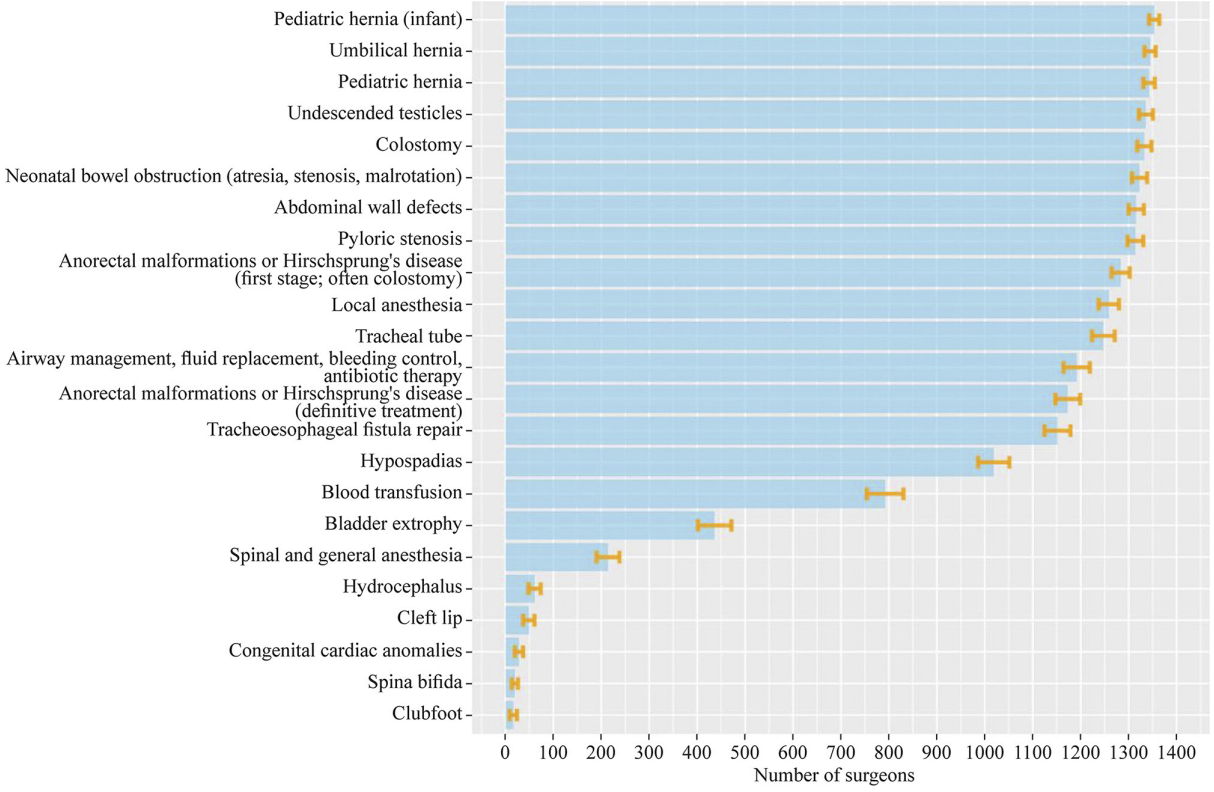

Figure 2 Interventions for congenital conditions performed by Brazilian pediatric surgeons. Pediatric surgeons across were asked to report which of the Disease Control Priorities Third Edition essential congenital conditions they treat. Estimated counts of pediatric surgeons based on weighted responses and 95% CIs are provided. These conditions represent the core minimum congenital operations available in a mature health system. The majority of Brazilian pediatric surgeons manage 16 of these conditions.

Table 3 Interventions for congenital conditions performed by public versus private surgeons

Procedure (%)	Total	Private sector	Public sector	P value
Pediatric hernia (infant)	98	98	98	0.90
Pediatric hernia	98	99	97	0.08
Umbilical hernia	97	99	97	0.10
Undescended testicles	97	99	96	0.06
Colostomy	97	98	96	0.42
Neonatal bowel obstruction (atresia, stenosis, malrotation)	96	97	96	0.38
Pyloric stenosis	95	97	95	0.45
Abdominal wall defects	96	97	95	0.18
Anorectal malformations or Hirschsprung's disease (first stage; often colostomy)	93	93	93	0.87
Local anesthesia	91	88	93	0.19
Tracheal tube	91	90	90	0.82
Airway management, fluid replacement, bleeding control, antibiotic therapy	87	81	88	0.15
Anorectal malformations or Hirschsprung's disease (definitive treatment)	85	90	83	0.09
Tracheoesophageal fistula repair	84	91	81	0.01
Hypospadias	74	78	72	0.28
Blood transfusion	57	40	64	<0.01
Bladder exstrophy	32	28	33	0.33
Spinal and general anesthesia	15	8	19	<0.01
Cleft lip	3.5	3	4	0.90
Hydrocephalus	4.4	6	4	0.40
Congenital cardiac anomalies	2	4	1	0.16
Spina bifida	1	2	1	0.27
Clubfoot	1	1	1	0.88

Comparison of interventions performed for congenital conditions included in the DCP3 report between primarily public versus private surgeons. Percentages are based on weighted proportions. P values were calculated using Adjacent Wald χ^2 tests.
DCP3, Disease Control Priorities Third Edition.

both the public and private sectors, surgical infrastructure and reimbursement issues remain the primary issues reported by surgeons in both sectors.

Brazil has 1514 registered pediatric surgeons according to the most recent Demografia Medica 2020, representing 0.3% of all medical specialists in the country and a workforce ratio of 0.72 pediatric surgeons/100 000 persons. Pediatric surgeons are unevenly distributed throughout the country, concentrated in the southeast region (52.6%), followed by the south (17.1%) and northeast (16.8%), with fewer pediatric surgeons in the midwest (9.2%) and north (4.3%).[25] This distribution of professionals is likely determined by market availability, remuneration level, the structure of support services (pediatric intensive care unit, clinical neonatal care, high-level anesthesia), and the quality of life offered to professionals.[25] Another explanation for the oversupply of pediatric surgeons in the wealthier regions suggested by Aguiar *et al* is the large pediatric population assisted by private health insurance plans in these regions.[26] Notably, 70% of private insurance users are concentrated in the southeast region.[25 27]

Brazilian public and private health systems coexist not only in financing and management but also in the provision and use of health services. All Brazilians are covered by the SUS, and almost 100% use it for vaccines, prehospital care, and pharmaceutical assistance, while 75% of Brazilians depend exclusively on it. Users transfer between the systems based on opportunity and the ability to pay for health services to avoid bottlenecks as do health professionals, according to working conditions and remuneration.[27] This complex interplay between the public and private system in Brazil results in many physicians working in both systems risking unnecessary duplication of services, but also promoting knowledge exchange and reducing public sector burden.[28 29] Our results demonstrating the challenges in establishing a balance of pediatric surgery providers to address the demands of both systems mirror this complexity.

In Brazil, it is also common for highly specialized providers to have to work outside of their specialized training domain, which disrupts the availability of specialized care. One possible cause is fewer job offers for specialists in the public health service (SUS), the largest

Table 4 Interventions for congenital conditions performed by hospital level

Capacity (%)	First-level hospital	Second-level hospital	Third-level hospital	National children's center	P value
Airway management, fluid replacement, bleeding control, antibiotic therapy	74	88	85	92	0.14
Blood transfusion	57	59	53	67	0.12
Tracheal tube	95	95	90	86	0.32
Local anesthesia	100	94	91	88	0.005
Spinal and general anesthesia	17	17	16	14	0.89
Pediatric hernia	100	98	97	97	0.08
Pediatric hernia (infant)	100	99	98	98	0.18
Umbilical hernia	100	99	98	96	0.06
Pyloric stenosis	95	99	95	93	0.66
Colostomy	100	99	96	96	0.06
Neonatal bowel obstruction (atresia, stenosis, malrotation)	95	98	96	96	0.98
Tracheoesophageal fistula repair	67	84	85	83	0.27
Clubfoot	0	2	0.6	2.3	0.14
Cleft lip	9	5.3	2.3	4	0.54
Anorectal malformations or Hirschsprung's disease (first stage; often colostomy)	92	98	92	94	0.93
Anorectal malformations or Hirschsprung's disease (definitive treatment)	86	85	84	88	0.69
Abdominal wall defects	97	100	95	95	0.76
Hydrocephalus	0	4	6	2	0.004
Congenital cardiac anomalies	0	2	2	4	0.04
Spina bifida	0	3	0	2	0.06
Bladder exstrophy	12	40	29	40	0.05
Undescended testicles	100	98	97	96	0.09
Hypospadias	60	84	75	67	0.16

Comparison of interventions performed for congenital conditions included in the DCP3 report between each of four hospital levels. Percentages are based on weighted proportions. P values were calculated using Adjacent Wald χ^2 tests.
DCP3, Disease Control Priorities Third Edition.

employer of doctors in the country, which employs mainly emergency workers and general specialty doctors.[25] Our results corroborate that pediatric surgeons still work as general surgeons, even in places with a shortage of pediatric surgeons.[25]

Of the 23 essential interventions outlined as essential interventions for congenital care, Brazilian pediatric surgeons provide over half of them, the rest of which represent procedures provided by other surgical subspecialties.[17] Brazilian pediatric surgeons operate on all pediatric surgical diseases, except for ophthalmological, ear, nose and throat, orthopedic, cardiac, and neurosurgical diseases. They also treat children's urological, thoracic, and reconstructive plastic surgeries for congenital diseases. This range of care is different from pediatric surgery care distribution in most European and North American countries and makes capacity assessments for pediatric surgical care between countries difficult.[25] The objective of investigating the performance of pediatric surgeons using the DCP3 priority list is not to assess if these surgeons would perform all the protocol procedures but instead to measure the contribution of these professionals in the care of children with congenital malformations according to a validated and recognized priority guide. Understanding which procedures are performed, in which places, and with which resources can help in more strategic planning for allocating resources and professionals. Most importantly, in a continental country such as Brazil, we need to understand the disparities of surgical education and provision of care within the country. Our results indicate that Brazilian pediatric surgeons are receiving homogeneous training and practice broadly across the country. The mixed private–public health system contributes to competition that maintains high-quality care in the public system and offers Brazilian surgeons opportunity

Table 5 Barriers by public versus private sector

Barrier (%)	Total	Public	Private	P value
Lack of anesthesia care	24	25	21	0.32
Lack of equipment	60	62	56	0.35
Lack of access to operating rooms	29	30	26	0.43
Lack of essential medications	21	25	9	<0.01
Lack of infrastructure (such as electricity, water, vacuum)	11	11	11	0.93
Lack of postoperative hospital beds	46	52	32	<0.01
Difficulty obtaining reimbursement	57	61	47	0.03
Lack of more specialized training	28	28	25	0.47
Lack of reference systems for patient transfer	26	25	27	0.8
Poor patient access (geographical distance, low socioeconomic status)	40	43	31	0.04
No barriers	11	10	14	0.18

Comparison of barriers reported by pediatric surgeons who work primarily in the public sector (SUS system) versus the private sector. Number is estimated based on sample weight, and percentages are based on weighted proportions. P values calculated using adjacent Wald χ^2 tests.
SUS, Sistema Único de Saúde.

for better income without foregoing working in the public system entirely.

The majority of interventions were performed by surgeons working in both the public and private sectors suggesting that human resources exist to provide the full range of congenital surgical care in the public sector. As our results demonstrate, pediatric surgeons at Brazilian private institutions were less likely to provide general anesthesia or blood transfusions themselves, which may reflect better availability of anesthesia providers in the private institutions. Successful strategies for increasing capacity for children's surgical care in LMICs have consisted of expansion of the local pediatric workforce coupled with infrastructure development.[30 31] Our results in Brazil suggest that Brazil's UHC healthcare workforce is able and willing to perform the majority of complex congenital operations. Five per cent of pediatric surgeons work at first-level hospitals and perform complex surgery, which suggests that either regional triage to larger hospitals is not possible or that surgeons feel comfortable performing these operations at smaller, rural hospitals. Although surgeons report that they perform complex cases in first-level hospitals, the number of surgeons who reported barriers to care was systematically higher at first-level and second-level hospitals and at public hospitals when compared with private facilities. This reflects the

Table 6 Barriers by hospital level

Barrier (%)	First-level hospital	Second-level hospital	Third-level hospital	National children's center	P value
Lack of anesthesia care	3	39	22	22	<0.01
Lack of equipment	71	76	56	58	0.02
Lack of access to operating rooms	27	30	27	34	0.85
Lack of essential medications	30	32	17	17	0.10
Lack of infrastructure (such as electricity, water, vacuum)	40	17	6	11	0.03
Lack of postoperative hospital beds	45	56	41	50	0.20
Difficulty obtaining reimbursement	71	72	53	49	0.03
Lack of more specialized training	28	39	29	17	0.03
Lack of reference systems for patient transfer	45	34	21	24	0.13
Poor patient access (geographical distance, low socioeconomic status)	77	35	37	46	0.05
No barriers	8	2	13	12	<0.01

Comparison of barriers reported by pediatric surgeons based on the hospital level where they perform the majority of their operations. Number is estimated based on sample weights, and percentages are based on weighted proportions. P values calculated using adjacent Wald χ^2 tests.

under-resourced nature of first-level and even second-level hospitals with respect to surgical care.[32 33] We also found that barriers to pediatric surgical care were more pronounced in public hospitals in Brazil, specifically the lack of access to equipment. This finding parallels other literature exploring barriers to provision of surgical care where lack of infrastructure has been shown to be the primary driver.[34 35]

In response to these barriers to surgical care provision and to better guide governments, a number of countries have begun to develop and implement National Surgical, Obstetric, and Anesthesia Plans (NSOAPs), which may help to coordinate efforts to scale up surgical infrastructure.[36–38] Although a number of countries in Latin America have adopted systems of UHC, none have implemented an NSOAP yet.[39] This underscores the need to develop context-specific plans, integrated into UHC systems, such as Brazil's healthcare system, that specifically address inequities in access to surgical care and more specifically, children's surgical care. Furthermore, an understanding of the differences in procedures performed in the public and private sector could help with further identification of indicator procedures that have been developed as markers of surgical capacity and delivery similar to the Bellwether procedures.[40 41] Addressing the lack of access to equipment and beds available to pediatric patients in public hospitals will be an important next step in improving the distribution of access to pediatric surgical care in the country.

Based on our results, the next challenges on promotion of quality pediatric surgical care in Brazil rely on (1) access, (2) transfer of care to higher-level facilities, and (3) availability of medications, (4) surgical equipment, and (5) other pediatric subspecialties such as pediatric anesthesia. These barriers are different from those faced by low-income countries, suggesting that categorizing barriers and problems for LMICs generally may be insufficient. Successful interventions in a low-income country, such as increasing the number of providers, may not be useful in an upper middle-income country such as Brazil. Future study directions include developing an understanding of how these barriers are affecting child mortality and disability and developing a priority agenda to address these barriers to achieve better equity in healthcare delivery and to advise health policymakers on allocation. These studies might also include qualitative interviews of healthcare professionals working in pediatric surgery to gain a more in-depth understanding of these barriers to providing high-quality care for children.

Our study has several limitations. First, our findings may be a narrow representation of all pediatric surgeons from Brazil. Surgeons participated voluntarily and may have had reasons to do so, resulting in self-selection bias. As the survey was distributed through online platforms, a surgeon's utilization habits for these platforms directly affected their exposure to the study. Not all pediatric surgeons in the country received the survey. In an attempt to adjust for this bias, we weighted responses by state to account for selection bias. After weighting the response data by regional distribution, there were no significant differences between the weighted and unweighted data. Additionally, our sample, representing one-fourth of all pediatric surgeons in Brazil, had a similar regional distribution to the reported regional distribution for the national pediatric surgeon workforce in both Demografia Medica 2018 and 2020. Another possible limitation is recall bias given that data for each surgeon on which procedures they perform are based on self-reporting with no measure of operative volume, skill, expertise, or outcomes. Additionally, we surveyed only pediatric surgeons, and no other surgical specialists who may also perform congenital operations. Further studies are needed to understand the role of other surgical subspecialists in the delivery of children's congenital surgical care within the context of Brazil's UHC system.

In conclusion, pediatric surgeons perform congenital operations equally across Brazil, in both the public and private sectors, as well as across various hospital tiers from district hospitals to large referral centers. While the majority of pediatric surgeons in Brazil work in public sector hospitals, few work solely in the public sector, and those who do face a number of barriers related to infrastructure, transfer arrangements, and access to other pediatric subspecialists. Policies and incentives that support pediatric surgeons working in the public sector may increase the quality of care of congenital surgical care, promoting better health outcomes. These policies and guidelines must consider that interventions for congenital anomalies take place across all hospital levels within the public and private sector and that coordinated systems to support public hospitals are needed.

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