Assessing the Brazilian surgical system with six surgical indicators: a descriptive and modelling study

Assessing the Brazilian Surgical System with Six Surgical Indicators: A Descriptive and Modeling Study

Running Head: Surgery in Brazil

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Financial Disclosures: There was no funding for this study. No authors have a financial interest in any of the products, devices, or drugs mentioned in this manuscript. Dr. Shrime reports speaking fees from Ethicon in January 2014, outside the submitted work.

Presentations: This paper will be presented at the 2016 Annual CUGH Global Health Conference in San Francisco, CA on April 9-11, 2016**.**

Author Contributions:

BBM: literature search, figures, study design, data collection, data analysis, data interpretation, writing

SS: literature search, figures, study design, data collection, data analysis, data interpretation, writing

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ABSTRACT:

Background: Brazil boasts a health scheme that aspires to provide universal coverage, but its surgical system has rarely been analyzed. In an effort to strengthen surgical systems worldwide, the Lancet Commission on Global Surgery proposed collection of six standardized indicators: two-hour access to surgery, surgical workforce density, surgical volume, perioperative mortality rate (POMR), and protection against impoverishing and catastrophic expenditure. This study aims to characterize the Brazilian surgical health system with these newly devised indicators while gaining understanding on the complexity of the indicators themselves.

Methods: Using Brazil's national healthcare database, commonly reported healthcare variables were used to calculate or simulate the six surgical indicators. Access to surgery was calculated using hospital locations, surgical workforce density was calculated using locations of surgeons, anesthesiologists and obstetricians (SAO), and surgical volume and POMR were identified with surgical procedure codes. The rates of protection against impoverishing and catastrophic expenditure were modelled using cost of inpatient hospitalization and a gamma distribution of incomes based on GINI and GDP/capita.

Findings: In 2014, SAO density is 34·7/100,000 population, surgical volume is 4,433 procedures/100,000 people and POMR is 1·71%. 79·4% of surgical patients are protected against impoverishing expenditure and 84·6% were protected against catastrophic expenditure due to surgery each year. Two-hour access to surgery was not able to be calculated from national health data, but a proxy measure suggested that 97·2% of the population has two-hour access to a hospital that may be able to provide surgery. Geographic disparities were seen in all indicators.

Interpretation: Brazil's public surgical system meets several key benchmarks. Geographic disparities, however, are substantial and raise concerns of equity. Policies should focus on stimulating appropriate geographic allocation of the surgical workforce. In some cases, where benchmarks for each indicator are met, supplemental analysis can further inform our understanding of health systems. This measured and systematic evaluation of surgical systems should be encouraged for all nations seeking to better understand their surgical systems.

Funding: There was no funding for this study.

What this paper adds:

What is already known on this subject:

- There is a substantial lack of surgical monitoring and evaluation worldwide.
- The Lancet Commission on Global Surgery (LCoGS) proposed the six surgical indicators used in the present study.
- Geographic disparities in the trainee and physician workforce have been reported, though no other studies were identified that characterized other elements of the surgical system of Brazil.

What this study adds:

- This is the first comprehensive and critical analysis of the surgical indicators proposed by LCoGS in any country, demonstrating that the collection of surgical system indicators is possible where national health data is recorded.
- This study provides an in-depth, multi-factorial assessment of Brazil's surgical system while also identifying and quantifying geographic disparities that exist.
- Recommendations for the LCoGS surgical indicators and for the Brazilian surgical system are summarized in Table 3.

INTRODUCTION:

In a 2015 report, the Lancet Commission on Global Surgery (LCoGS) estimated that over 5 billion people lack access to safe, affordable, and timely surgical care worldwide and that an additional 143 million surgical procedures are needed annually to meet global needs.[1 2] Recognizing the critical role of measurement in understanding and tracking the state of a surgical system, LCoGS proposed six standardized indicators, with associated benchmarks for two of them, (Table 1) and advocated for the incorporation of these indicators into existing mechanisms for health system assessments. While these indicators were developed through an expansive and iterative expert consultation, they have not yet been comprehensively applied at the national level.

Brazil, the world's fifth most populous country, aspires to provide universal health coverage. As such, it is an optimal pilot site for studying these indicators. The country is comprised of five regions, which are further divided into 26 states and a federal district. In the 1980s, Brazil was the world's most unequal country[3] with the South and Southeast regions representing a significantly wealthier population than the rest of the country. Nevertheless, the nation has experienced rapid economic growth and decreasing inequality, leading to demands for better public services, including improvements in healthcare.[4]

For many health indicators, the country has made improvements: life expectancy in Brazil has increased by nearly 20 years in the past 4 decades[5] and maternal mortality has nearly been cut in half.[6] The government's health scheme, *Sistema Único de Saúde* (SUS) or the Unified Health System, is credited for many of these improvements as the largest public healthcare system in the world, guaranteeing healthcare to 100% of the Brazilian population.[7] It is federally funded with additional tax revenues and social contributions from the individual states and municipalities. The financing for SUS is largely governed at the federal level, though healthcare administration and management is left to states and municipalities.[7] Unfortunately, SUS is vulnerable to the geographic and economic disparities that beleaguer the country. For example, 65·9% of doctors in Brazil practice in the state capitals while only 24% of the national population lives there.[8] Similarly, only 56% of physicians practicing in the North completed residency training compared to 78% of physicians practicing in the Southeast.[8]

This maldistribution of services is seen in the surgical disciplines as well. Surgical residency began in Southeastern cities in 1948, and even in 2008, 73% of general surgery training positions remained in the South and Southeast.[9] While disparity in availability and quality of surgical care is widely acknowledged,[8-10] it has not yet been systematically studied.

The primary goal of this study is to characterize the Brazilian surgical health system according to the six indicators proposed by LCoGS. In doing so, we will provide an in-depth assessment of Brazil's surgical system while also identifying and quantifying geographic disparities that exist. We also use Brazil to gain further understanding of the complexity of these newly proposed indicators.

METHODS:

Data were obtained from national, open-access databases that are organized and maintained by the government. DATASUS is the online portal for an administrative database SIH/SUS (http://www2.datasus.gov.br). SIH/SUS categorizes all SUS payments for hospitalizations and procedures and has been used in numerous studies.[11] *Instituto Brasileiro de Geografia e Estatistica* (IBGE) is the national geographic and statistical database (http://www.ibge.gov.br). We accessed all databases in September 2015.

Indicator 1: Two-Hour Access to Surgery

In the Lancet Commission on Global Surgery, two-hour access to surgery is defined as the proportion of the population that can access a facility that can perform caesarean delivery, laparotomy and open fracture repairs within two hours.[1] Because facility-level data on these procedures was unavailable, we queried the *Cadastro Nacional de Estabelecimentos de Saúde* (CNES), a portal within DATASUS, for public hospitals that employ at least one surgeon, anesthesiologist and obstetrician, and have a doctor on call 24 hours per day. As such we were unable to calculate a true indicator 1 and the provided list is simply a proxy measure.

Using proprietary software from Redivis (https://www.redivis.com), the geographic location of these hospitals was mapped and two-hour distance was calculated. Hospital location was entered using latitude and longitude and two-hour distance was estimated using known speed limits for roads and highways and average walking speed where no roads were present. Finally, the geographic area of the map generated to simulate two-hour access was compared against the population density, from WorldPop (www.worldpop.org.uk), in order to calculate the percentage of the population with two-hour access to an included facility.

Indicator 2: Surgical Workforce Density

Surgeons, anesthesiologists and obstetricians (SAO) were identified from CNES, which includes a count of all professionals registered in a municipality, for 2014. “Surgeons” included general surgeons, surgical oncologists, cardiovascular surgeons, orthopedic surgeons, hand surgeons, otolaryngologists, head and neck surgeons, pediatric surgeons, plastic surgeons, thoracic surgeons, vascular surgeons, ophthalmologists, urologists and neurosurgeons. “Anesthesiologist” and “Obstetricians” were categorized as such in DATASUS. A population estimate was obtained from IBGE and is based on census data and projected growth. The surgical workforce density that we reported was the total number of SAO per 100,000 population and was calculated separately for each state, region, and for the country as a whole.

Indicator 3: Surgical Volume

Surgical volume was identified using annual numbers registered in DATASUS for the year 2014. We included both inpatient and ambulatory surgeries in these fields: endocrine, peripheral and central nervous system, head and neck, ophthalmologic, vascular, gastrointestinal and abdominal, orthopedic,

genitourinary, breast, obstetric and gynecologic, thoracic, reconstructive, and oncologic. Exclusion criteria included anesthetic and dental procedures.

Indicator 4: Perioperative Mortality Rate

DATASUS reports mortality data on any deaths occurring during an inpatient hospitalization. Perioperative mortality rate (POMR) was calculated using inpatient mortality that occurred during a hospitalization in which a patient underwent a procedure.

Indicator 5: Protection against Impoverishing Expenditure

This indicator is defined as the proportion of households protected against impoverishment from out-of-pocket payment for surgical and anesthetic care. To determine impoverishment, we used the nationally determined poverty line.[12] The threshold for impoverishing expenditure would be any income below:

$$Average\ Cost\ of\ Surgery \cdot \%\ Out\ of\ Pocket\ Expenditure + [Poverty\ Line]$$

For the cost of surgery, we utilized average cost of surgery to SUS in Brazilian Reals, from 2008 to 2014, as reported in DATASUS. This value reflects the total cost to SUS of an inpatient hospitalization and associated costs during which the patient underwent a surgical procedure, as defined above. The expected proportion of out-of-pocket expenditure for healthcare is provided by the World Bank.[13] A well-validated descriptive model of income distribution, the gamma distribution, was used to generate income distributions for the country, regions, and states.[14] GDP per capita and the Gini Index were used as model parameters. The percentage of protection against impoverishing expenditure is the percentage of all incomes in the distribution that remain above the poverty line after the cost of surgery was deducted.

Indicator 6: Protection against Catastrophic Expenditure

Methods for determining income distributions are the same as in Indicator 5. Catastrophic expenditure, however, is defined as out-of-pocket expenditure on surgical and anesthetic care that is greater 40% of the patient's post-subsistence income where post-subsistence income is the household income after food expenditure. Thus, the threshold for catastrophic expenditure is any income below:

$$[Average\ Cost\ of\ Surgery] \cdot \%\ Out\ of\ Pocket\ Expenditure 0{\cdot}40 + Average\ Food\ Expenditure$$

As in Indicator 5, this income distribution was then compared against the cost of surgery to determine the percentage of people protected against catastrophic expenditure. Food expenditure data is available from 2008 at the state level. State food expenditure levels were modeled using the national economic index for years 2009-2014.

Ethics Statement

This study was conducted according to the principles expressed in the Declaration of Helsinki. This study was granted an IRB exemption by Boston Children's Hospital and an ethics exemption from the Faculdade de Medicina da Universidade de São Paulo. The authors have no conflicts of interest and there was no funding source for this study.

Statistical analysis

To compare the regional variation in modeled parameters (indicators 5 and 6), ANOVA was performed. No statistical analysis was performed on tabulated data (indicators 2-4). All statistical analyses were performed using statistical program, R, and Microsoft Excel. Geographic mapping and analysis was performed using the geographic information system package, QGIS to visualize geospatial information generated or tabulated in R and Microsoft Excel.

RESULTS:

Indicator 1: Two-Hour Access to Surgery

Our query from the CNES yielded 1,247 hospitals that met criteria nationwide. We calculate a proxy-measure for indicator 1 in which 97·2% of the population of Brazil has two-hour access to a facility that may be able to provide surgery.

Indicator 2: Surgical Workforce Density

The surgical workforce density was 34·7 SAO per 100,000 population in 2014 (Table 2, Appendix 1). Geographically, this ranges from 18·4 SAO per 100,000 people in the North Region, to 45·81 SAO per 100,000 people in the Southeast, in 2014 (Figure 1a, Table 2). Of the total 70,449 SAO in Brazil, 40,808 are surgeons (58·9% of the surgical workforce), 11,492 are anesthesiologists (16·3%), and 18,149 are obstetricians (25·8%).

The density of the surgical workforce that operates in the public sector drops to 23·0 SAO per 100,000 people. 57·9% of all surgeons, 82·7% of all anesthesiologists, and 63·1% of all obstetricians maintain a job in the public sector.

Indicator 3: Surgical Volume

Surgical volume in the public sector was 4,433 surgeries per 100,000 people in 2014. Geographically, this ranges from 3,518 surgeries per 100,000 people per year in the North Region, to 5,151 surgeries per 100,000 people per year in the Central West, in 2014 (Figure 1b, Table 2).

Indicator 4: Perioperative Mortality Rate

Perioperative mortality rate was 1·71% in 2014, ranging from 1·12% in the North to 2·13% in the South, in 2014 (Figure 1c, Table 2). The mean inpatient stay for a surgical admission in Brazil was 3.6 days in 2014.

The perioperative mortality rate for a cesarean section alone is 0.034% in Brazil. The rate is highest in the Northeast (0.037%) and lowest in the South Region (0.025%).

Indicator 5: Protection against Impoverishing Expenditure

Protection against impoverishing expenditure was 79·4% in 2014, ranging from 68·7% in the Northeast Region, up to 82·3% in the Central West Region, in 2014 (Figure 1d, Table 2).

Indicator 6: Protection against Catastrophic Expenditure

Protection against catastrophic expenditure was 84·6% in 2014, ranging from 78·5% in the Northeast Region, up to 87·2% in the Central West Region, in 2014 (Table 2).

DISCUSSION:

We used the Brazilian public health sector database to characterize Brazil's surgical system according to six indicators. Based on limited international data, we find that Brazil falls within the range of values seen by other upper-middle income countries and performs substantially better than low-income countries.[1 15] Moreover, we find that Brazil approaches or meets benchmarks that suggest adequate national workforce and surgical volume, yet the country suffers from problems of geographic distribution and equity. This analysis of the surgical system is timely in light of a recent survey of the Brazilian public which found that 93% of people have a negative perception of Brazilian healthcare, with access to surgery as the largest perceived problem.[10]

Despite the existence of a national health program, regional variation in the surgical indicators mirror economic and health disparities in the country. The North and Northeast, the two poorest regions of Brazil, have a lower density of surgical providers, fewer surgical procedures performed per capita, and more patients are impoverished due to surgery. In some cases, the disparity is severe. In the Northeastern state of Piaui, nearly 40% of patients, twice the national figure, are impoverished due to surgical costs. Additionally, in the Northeastern state of Maranhão, there are eight times fewer SAO/100,000 people than in the capital district of Brasilia (11·4 versus 88·6, respectively).

Workforce shortages have long been perceived to be a problem in the Brazilian health system.[16] For specialist surgical care, we found the wealthier regions meet benchmarks for density of surgical providers but that poorer North and Northeastern regions in Brazil barely meet the threshold of 20-40 SAO/100,000 that is a suggested minimum to meet a region's needs.[1 17] To address a general shortage of doctors, in 2013 the Brazilian government launched the *Mais Médicos* (More Doctors) scheme.[18] The scheme's primary focus is on increasing the number of primary care doctors and strengthening Primary Healthcare Units.[18] In addition to this, the scheme strives to increase medical school enrollment outside of state capitals and create 12,400 residency spots by 2018; the goal of this is to ensure every Brazilian medical graduate is able to pursue post-graduate training and that they are able to do so closer to the communities they come from.[18]

While the focus of this effort is on increasing training for primary care specialties, a parallel effort in surgical care is warranted. Increasing surgical and anesthesia training in rural areas may be a useful retention strategy for the rural surgical workforce, as has been demonstrated at a hospital in Kenya.[19] The development of a National Specialist Registration, currently underway, is likely to assist in identifying targets for public policies on specialist training.[18] For example, the shortage of anesthesiologists – the SAO workforce in brazil is comprised of 16·3% anesthesiologists, under the worldwide median of 20%[15] – suggests that reallocating residency spots may be useful.

Apart from geographic analyses, in a country such as Brazil where broad benchmarks of SAO density are met, additional disaggregation is also valuable. We find, for example, the SAO density of public sector providers is lower than overall providers by nearly 12 per 100,000. True availability is likely even worse than our numbers show: in Brazil, over half of all of the physicians have three or more job positions and 70·5% of all physicians in the public sector also work in the private sector.[16] The time distribution of time each specialist spends in the public versus private sector may be heavily biased towards the private

sector. Thus consideration of public full-time equivalents may give a more accurate picture of the surgical workforce available to the 75-80% of Brazilians who rely exclusively on SUS.[20]

In Brazil, the national surgical volume of 4,337 procedures / 100,000 *in the public sector alone* is close to the suggested minimum of 5,000 procedures / 100,000. In light of this, it is important to turn attention to quality and case-mix of the surgeries being performed and the appropriateness of personnel to do them. In particular, selective overprovision of surgeries such as cesarean section[21-23] may be harmful to patients and draw resources away from the provision of other necessary procedures.

Additionally, an integrated consideration of the indicators is valuable. We find, for example, the state of Rio de Janeiro has a high workforce density yet provides a very low number of procedures in the public sector yielding a ratio of 41.7 procedures per SAO provider. The state of Pará, conversely, has high public sector output with a low workforce density, with a ratio of 305.2 procedures per SAO provider. These findings may be driven by the fact that surgeons in Rio disproportionately provide care in the private sector. Further investigation into this type of variation is warranted.

Our study also found that inpatient POMR demonstrates a counterintuitive geographic disparity. The South and Southeastern states, which have a greater proportion of academic surgical programs,[9] suffer a considerably higher POMR than the Northern and Northeastern states. This may, in part, be driven by different patient populations, different physician behavior, or underreporting of mortality. In the South and Southeast, more highly trained surgeons with greater resources may perform higher-complexity procedures on patients with greater comorbidities, thereby driving up POMR. POMR for cesarean section alone, a procedure for which there is less variation of risk, demonstrates the expected findings of lower POMR in the South and Southeast than in the North and Northeast. An additional factor may be underreporting of mortality, which is known to occur with greater frequency in the North and Northeast of Brazil than in other regions.[24]

It is additionally worth noting that our definition of POMR evaluated mortality over the duration of the inpatient hospitalization. Recent studies of POMR in Brazil, have reported substantially lower mortality rates ranging from 0.16% to 0.51% in tertiary hospitals in São Paulo.[25 26] These studies, however, have been single-center studies with a follow-up period no greater than 24 hours from procedure. The POMR we report is provided over a much longer duration of follow-up.

Worldwide, 33 million people each year face catastrophic expenditures due to surgical costs.[1 27] SUS strives to mitigate this for Brazilians by eliminating user fees. The World Bank, however, estimates that 29·9% of public health expenses in Brazil are passed on to the patient as out-of-pocket expenditure.[13]' While studies have reported much of this expenditure is on non-procedural costs such as medicines,[28 29] it is likely that the associated expenses of surgery exert a substantial burden on low-income families. Non-medical costs such as transportation – which were not accounted for in our study – can also amount to an enormous economic burden.[30] As SUS strives to truly achieve universally affordable surgical care, consideration of these out-of-pocket expenses and how they may vary by region is critical. To do so, will require an understanding of patient perspectives on financing for healthcare.

This study has limitations. Notably, we were not able to calculate two-hour access to a surgical facility due to the fact that we could not accurately identify which hospitals are currently equipped with

operating rooms, which hospitals have on-call anesthesiologists, and which hospitals have physicians capable of the performing cesarean section, management of open fractures, and laparotomy. Because of this, the proxy measure we report likely overestimated the population's true two-hour access to surgical care. Furthermore, our estimation assumes access to a motor vehicle, no road traffic, and the presence of a functional operating room at the hospital. A true measurement of two-hour geographic access would require facility-level analysis of hospital surgical capabilities, workforce availability with full-time equivalents, and patient transportation methods. In order to carry this out on a population level, a sampling strategy would likely need to be used and extrapolated. Further studies exploring this particular indicator are warranted. Moreover, this indicator could be buttressed by reporting operating theater density / 100,000.

An additional limitation of our data is the fidelity of our data sources. Reporting concerns have been raised about admission diagnoses in DATASUS, though this is a parameter we did not use in our analysis.[11] In addition to variable mortality reporting, misreporting of employment is thought to be prevalent, as DATASUS collects data on job titles but not necessarily on actual specialist training. While we are able to estimate indicator 2 from this data, it is limited by the dataset it is drawn from. Similarly, out of pocket spending on healthcare likely differs by income level[28] which could lead to our reported numbers for indicators 5 and 6 underestimating the true value.

A final limitation of our study is its focus on the public sector. While SUS is available to all, there remains a complex private-public mix for healthcare provision.[5 31] This public spending on healthcare accounts for 4.7% of GDP[32] while private spending is thought to account for an additional 5·0% of GDP.[33] Private insurance covers between 20-25% of the population[20] and private facilities frequently care for both SUS and private patients. Nevertheless, our findings apply to the system that cares for the vast majority of Brazilians.

Despite these limitations, this study is able to utilize a detailed and publicly available dataset along with robust modelling techniques to provide a systematic analysis of Brazil's surgical system. We evaluate areas of surgical preparedness, care delivery, and financial impact on patients. Our analysis is unique in its evaluation of surgical care *at the state level* and provides insight into regional variability. From our assessment we are able to identify areas in which Brazil's surgical system can be improved while also gaining insight into these newly proposed surgical indicators. These findings are summarized in Table 3.

CONCLUSIONS:

Brazil is a vast and populous country with a public surgical system that should be applauded for meeting several key benchmarks. Nevertheless, dissatisfaction with surgical care in Brazil remains high.[9] Our analysis points to large geographic disparities which raise concerns of equity. Policies should focus on stimulating appropriate geographic allocation of the surgical workforce, addressing the deficits of certain specialists, and better distributing surgical volume. An integrated and in-depth consideration of these indicators will uncover various inequities in care provision that must be further investigated and addressed. This may involve patient- and facility-level analyses to better understand key issues related to geographic and financial access to car or careful consideration of quality of care when other indicator benchmarks are met.

This study also demonstrates that the collection of surgical system indicators is possible where national health data is recorded and made available. This type of analysis can be encouraged for all nations seeking to understand their surgical systems.

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TABLE AND FIGURE LEGENDS:

Table 1: Six Lancet Indicators for measurement and assessment of global surgical systems.

Table 2: Indicators 2 through 6 for each region in Brazil, in the year 2014. SAO: surgeons, anesthesiologists, and obstetricians; Vol: Surgical Volume; POMR: Perioperative Mortality Rate; C/S: Caesarean Section; CI: confidence Interval; *One Way ANOVA performed between regions

Table 3: Recommendations for surgical system strengthening in Brazil and globally for the Lancet Indicators.

Figure 1a: Indicator 2: Total surgeon, anesthesiologist, and obstetrician workforce density per 100,000 people, by state in the year 2014.

Figure 1b: Indicator 3: Total surgical volume per 100,000 people, by state in the year 2014.

Figure 1c: Indicator 4: Perioperative mortality rate by state, in the year 2014.

Figure 1d: Indicator 5: Protection against impoverishing expenditure by state, in the year 2014.

Appendix 1: Indicators 2 through 6 for each region and state in Brazil, in the year 2014, with additional sub-indicators for physicians working in the public sector and cesarean section perioperative mortality rate. *SAO: Surgeons, Anesthesiologists, and Obstetricians; Vol: Surgical Volume; POMR: Perioperative Mortality Rate; CS: Cesarean Section; CI: Confidence Interval; *One Way ANOVA performed between regions*

Table 1: Six Lancet Indicators for measurement and assessment of global surgical systems.

Group 1: Preparedness for surgical and anesthesia care		**Targets**
Access to timely essential surgery	Proportion of the population that can access, within 2 hours, a facility that can do caesarean delivery, laparotomy, and treatment of open fracture (the Bellwether Procedures)	A minimum of 80% coverage of essential surgical and anaesthesia services per country by 2030
Specialist surgical workforce density	Number of specialist surgical, anesthetic, and obstetric physicians who are working per 100 000 population	100% of countries with at least 20 surgical, anaesthetic, and obstetric physicians per 100 000 population by 2030
Group 2: Delivery of surgical and anesthesia care		
Surgical volume	Procedures done in an operating theatre, per 100 000 population per year	Minimum of 5000 procedures per 100 000 population by 2030
Perioperative mortality rate	All-cause death rate before discharge in patients who have had a procedure in an operating theatre, divided by the total number of procedures, presented as a percentage	*No target set. Will be re-evaluated upon further data collection*
Group 3: Effect of surgical and anesthesia care		
Protection against impoverishing expenditure	Proportion of households protected against impoverishment from direct out-of-pocket payments for surgical and anesthesia care	100% protection against impoverishment from out-of-pocket payments for surgical and anaesthesia care
Protection against catastrophic expenditure	Proportion of households protected against catastrophic expenditure from direct out-of-pocket payments for surgical and anesthesia care	100% protection against catastrophic expenditure from out-of-pocket payments for surgical and anaesthesia care by 2030

Adapted from The Lancet Commission on Global Surgery

Table 2: Indicators 2 through 6 for each region in Brazil, in the year 2014.

Region/State	Indicator 2 SAO/100,000	Indicator 3 Vol/100·000	Indicator 4 POMR	Indicator 5 mean (95% CI)	Indicator 6 mean (95% CI)
North Region	18·42	3518·58	1·12	73·85 (73·85-73·85)	82·24 (82·23-82·24)
Northeast Region	23·59	4190·93	1·38	68·7 (68·7-68·7)	78·49 (78·49-78·49)
Southeast Region	45·81	4742·72	1·87	82·64 (82·64-82·64)	86·59 (86·59-86·59)
South Region	30·76	4163·59	2·13	81·39 (81·39-81·39)	84·77 (84·77-84·78)
Central West Region	40·03	5151·20	1·55	82·27 (82·27-82·27)	87·15 (87·15-87·15)
Brazil	**34·74**	**4433·44**	**1·71**	**79·39 (79·39-79·39)**	**84·58 (84·58-84·59)**
p Value*	---	---	---	<0·01	<0·01

*SAO: Surgeons, Anesthesiologists, and Obstetricians; Vol: Surgical Volume; POMR: Perioperative Mortality Rate; CI: Confidence Interval; *One Way ANOVA performed between regions*

Table 3: Recommendations for surgical system strengthening in Brazil and globally for the Lancet Indicators.

Indicator	Surgical System Strengthening in Brazil	Global Application of the Lancet Indicators
Indicator 1: Access to timely essential surgery	• Facility-level data is needed	• Facility level data is needed • Look at operating room density/100,000 population as adjunct indicator when basic parameters of access are met
Indicator 2: Specialist surgical workforce density	• Address large geographic disparities for SAO • Consider rural residency training in addition to rural medical education • Address the shortage of anesthesia providers	• Disaggregate the surgical workforce density by specialty to find nuances • Assess internal distribution to look for regional deficiencies • Use full-time equivalent of SAO in the public sector as an adjunct indicator
Indicator 3: Surgical volume	• Measure and report private surgical volume • Address geographic disparities in public-sector volume • Monitor overuse as access continues to improve	• Assess internal distribution to look for regional deficiencies • Monitor overuse by evaluating case-mix
Indicator 4: Perioperative mortality rate	• Ensure accurate reporting • Develop a national strategy for assessing and improving postoperative outcomes	• Consider procedure-specific perioperative mortality rates to minimize variation in patient-risk
Indicator 5 and 6: Protection against impoverishing and catastrophic expenditure	• Investigate what expenditures are being passed on to the patient • Expand financial risk-protection beyond the cost of procedures	• As an adjunct, consider patient-level analyses to disaggregate what contributes to out-of-pocket expenditure