Purpose: In Brazil, a country with major health access disparities, resource limitations make management of pancreatic cancer (PC) challenging. This study evaluated curative-intent surgery for PC in the Brazilian public health care system.

Methods: We collected data for PC surgical procedures with curative intent in Brazil’s public health care system (DATASUS) and from the demographic database. Costs, lengths of stay, number of perioperative deaths, and PC deaths were analyzed for each state and then associated with population, gross domestic product (GDP) per capita, and number of procedures.

Results: A total of 37,142 patients died as a result of PC in Brazil between 2008 and 2012. The number of deaths (per 100,000 person-years) was highest in the south and southeast regions. Mortality from PC had a positive association with the number of procedures and GDP per capita. Between January 2008 and July 2014, 3,386 procedures were performed, the majority (51.2%) in the southeast region. Four hundred ninety-three patients died, which translates to an inpatient mortality rate of 14.6%. The northern states had the highest perioperative mortality (mean, 25%). The number of procedures per 100,000 residents was higher in the southeast and south. Overall, cost tended to increase as the number of procedures or population increased. For fixed GDP per capita and population, cost tended to increase as the number of procedures increased, whereas for a fixed number of procedures and GDP per capita, cost tended to decrease as population increased. The mean length of hospital stay was 16.9 days, which was higher than in major international centers.

Conclusion: This study is the first to our knowledge to evaluate regional disparities in PC care in Brazil. Perioperative mortality was high in the public health care system. Regionalized policies that improve care are needed.

INTRODUCTION

Pancreatic cancer (PC) is an aggressive tumor with high lethality; 95% of patients with PC die within 1 year. In Brazil, an estimated 8,710 deaths were a result of PC in 2013. Worldwide, the annual number of deaths as a result of PC is approximately 265,000.

The most common histologic type is ductal adenocarcinoma, which accounts for 85% of cases. The head of the pancreas is the most common site of occurrence (70% of cases); therefore, the main therapeutic options for surgical treatment are complex and morbid operations, such as pancreaticoduodenectomy (Whipple procedure) or partial pancreatectomy plus lymphadenectomy. However, this curative-intent treatment is only possible in approximately 20% of patients.

The Brazilian Federal Constitution states that “health is a right of all citizens and a duty of the state,” but although the national public health care system is universal, it is not integral, and numerous regional disparities and inefficiencies exist. This health access disparity is much more evident in the north and northeast regions, which have lower levels of social and economic development compared with the south and southeast. This study assessed the impact of Brazilian regional socioeconomic inequalities in the surgical treatment of PC.

METHODS

Data for surgical procedures performed with curative intent for PC in Brazil’s public health care system from January 2008 to July 2014 in each of...
We obtained the crude number of procedures, costs, lengths of stay, perioperative-related deaths, and deaths from PC from the DATASUS system (Ministry of Health) and overall PC mortality for all International Classification of Diseases, 10th revision, code C25-related deaths for the entire Brazilian population.8,9 We retrieved procedure-related deaths from every procedure (pancreatoduodenectomy or partial pancreatectomy) paid by the public system.10 The Brazilian Institute of Geography and Statistics was the source of socioeconomic data, such as population size and gross domestic product (GDP) per capita.11 The unit of analysis for this study was each state of the Federation. PC-specific mortality rate, mortality related to surgical procedure, cost, and length of stay, and their respective associations or lack thereof with number of procedures, GDP per capita, and population were examined in the context of linear regression models, with each state’s observation weighted by its number of procedures or, in the case of PC-specific mortality rate, its population. P ≤ .05 was considered statistically significant. We analyzed all data with R 3.1.1.12

RESULTS

We collected all data in August 2014 and analyzed procedure-related data from January 2008 to July 2014. We retrieved overall PC mortality data from 2008 to 2012. The Brazilian Institute of Geography and Statistics collected major socioeconomic and demographic data in the latest
national census of 2010. In the Brazilian public health care system, there were 3,386 curative-intent surgical procedures for PC performed during the study period. The southeast region (the states of São Paulo, Rio de Janeiro, Minas Gerais, and Espírito Santo) comprised 51% of these operations (Fig 1), and São Paulo, home to 21.6% of Brazilians, accounted for 32.7% of the procedures performed in the country. This disparity proves more evident when we see that the north and northeast performed 16.2% of surgeries (and 37.5% of population).

The total number of deaths related to PC recorded in DATASUS was 37,142 in the period between 2008 and 2012. Mortality as a result of PC was higher in states in the southeast and south regions (5.98 and 4.64 per 100,000 person-years, respectively) and lower in the other regions (Fig 2). PC mortality correlated with number of surgical procedures, GDP per capita, and population (Table 1). However, on multivariable analysis, only the number of surgical procedures and GDP per capita had an independent influence on PC mortality. Therefore, for a fixed value of GDP per capita, PC mortality increased with the number of procedures performed (increase of 0.47 per 100,000 person-years for every increase of 100 procedures performed; 95% CI, 0.02 to 0.92; \(P = .04\)). Furthermore, for a fixed number of procedures per capita, PC mortality increased with GDP per capita (increase of 0.72 per 100,000 person-years for every increase of Brazilian real [R$] 10,000; 95% CI, 0.06 to 1.38; \(P = .033\)).

Mortality rates for pancreaticoduodenectomy and partial pancreatectomy are usually < 5% when performed in major international centers.\(^\text{13}\) During the study period, 493 procedure-related deaths were recorded, which represent a mortality rate of 14.6% for the public health care system as a whole. Procedure-related mortality was even higher in the northern states (25%) and reached 33% and 38% in the two states that had the worst results (Pará in the north and Sergipe in the northeast, respectively; Fig 3). In both univariable and multivariable analyses, procedure-related mortality was not associated with the number of procedures, GDP per capita, or population (Table 2).

The total cost related to the procedures in Brazil during the study period was R$ 21,528,306.78 (R$ 4 = US$1). The southeast region and the state of São Paulo had the highest spending (R$ 11,290,016.88 and R$ 7,651,514.49, respectively). The total costs for the surgical treatments correlated with total population and number of procedures in both univariable and multivariable analyses but not with GDP per capita (Table 3). The mean length of stay in patients with PC who underwent pancreaticoduodenectomy and partial pancreatectomy was 16.9 days (Fig 4). No major differences were found across regions, but the length of stay ranged from 6.9 days in Rio Grande do Norte (northeast) to 27.7 days in Rondônia.

### Table 1 – Relationship Between Pancreas Cancer–Specific Mortality and Number of Procedures, GDP Per Capita, and Population

|                | Univariable |         |       | Multivariable |         |
|----------------|-------------|---------|-------|---------------|---------|
|                | Coefficient (95% CI) P | Coefficient (95% CI) P |
| No. of procedures | 0.24 (0.12 to 0.36) < .001 | 0.47 (0.02 to 0.92) .04 |
| GDP per capita   | 1.18 (0.68 to 1.68) < .001 | 0.72 (0.06 to 1.38) .033 |
| Population      | 0.57 (0.18 to 0.95) .004 | −1.04 (−2.24 to 0.17) .092 |

Abbreviation: GDP, gross domestic product.
The objective of this study was to evaluate the impact of socioeconomic inequalities on the performance of curative-intent surgery for PC in Brazil. By using aggregated data from the Brazilian government, we examined the number of surgeries performed, overall PC mortality, perioperative mortality, cost, length of stay, GDP per capita, and population for each of the 27 federal states.

Brazil is a country of continental dimensions with intermediate human development, a universal public health care system, and significant regional disparities. Approximately 75% of the population relies solely on the public health care system for access to care. Inequalities in the Brazilian public health care system have been well documented. Santos et al. demonstrated a shortage of computed tomography scanners in the north and northeast and found that the number of scans performed in these regions is only 5% of the number performed in the United States. The country’s population is mainly located in the south and southeast, and these regions have the best economic and human development indicators within Brazil.

It is well-known that PC is more frequent in well-developed countries than in poorer ones. In Brazil, we observed this same pattern of incidence. The GDP is independently associated with an increased overall PC mortality. On multivariable analysis, the overall risk of death as a result of PC is independently higher in states with a higher GDP ($P = .033$). The positive and independent association between overall PC mortality and the rate of curative procedures (not the crude number of procedures) performed at the state level ($P = .04$) could be explained by migration of patients to high-volume states (but could not be explained by higher perioperative mortality in these states).

Curative-intent treatment is a challenge for patients with PC. Several factors are associated with morbidity, mortality, and treatment efficacy, such as nutritional and endocrine conditions, stage of disease, the presence of comorbidities, and performance status. These factors could not be included and controlled for in this analysis because such data are not available in DATASUS. After surgery, patients may also receive postoperative radiotherapy and chemotherapy, but even with adjuvant treatment, oncologic results are far from ideal. We were not able to assess the type and frequency of adjuvant treatments after the surgical procedure, which is a shortcoming of the current study.

The results suggest, however, that access to health care and the effectiveness of the public health care system are far from ideal in several Brazilian states. The number of surgical procedures is greater in southern and central Brazil and notably so in the state of São Paulo (the richest and most developed in the country). This finding is not justified by incidence estimates alone but probably by interregional migration in search of specialized treatment, which by law should be provided even in poorer states. The legal principle of universality and integrality of the health system, created by the 1988 Constitution and reinforced by law 8080 in 1990, is a worthy goal but one that has not been achieved. The association between PC mortality and GDP per capita is at least partly explained by the higher incidence of PC seen in the southeast and south, but it might also reflect patient migration to areas with better access to health services.

The procedure-related mortality and length of stay (simple surrogate measures of quality for surgeries) show the low quality of health services offered in the public system. In major international centers, procedure-related mortality rates are usually < 5%. Perioperative

### Table 3 – Relationship Between Surgical Costs and Number of Procedures, GDP Per Capita, and Population

| Univariable | Multivariable |
|-------------|---------------|
|             | $P$           |             | $P$           |
| No. of procedures | $0.1 (0.06 to 0.14) < .001$ | $0.32 (0.16 to 0.48) < .001$ |
| GDP per capita | $0.2 (-0.06 to 0.46) .136$ | $-0.2 (-0.41 to 0.02) .076$ |
| Population | $0.25 (0.12 to 0.37) < .001$ | $-0.57 (-0.99 to -0.15) .008$ |

Abbreviation: GDP, gross domestic product.
mortality was 14.6% for Brazil in the current study (far from acceptable), but it was even worse in the state of Sergipe where it reached 38%. Lack of facilities with adequate infrastructure, trained personnel, and, ultimately, funding may be a factor that impairs access to PC treatment. Moreover, the mean length of stay after surgery in Brazil was 16.9 days, also much longer than that found in major international centers (close to 7 days).16-18

On multivariable analysis, the number of procedures was not related to perioperative mortality. The unit of analysis is the state data rather than center or hospital data. We are aware that significant heterogeneity exists between high- and low-volume centers at the state level and that this could dilute the state volume impact on perioperative mortality. Unfortunately, the comparison of state-level with center-level data was not possible with the available data and, therefore, impractical.

The higher expenditure with PC surgery in the southeast suggests that this region has become a pole in the treatment of this pathology. The relative cost per procedure was also lower in the most populous states, which suggests economies of scale that lead to lower complication rates and increased savings.19

This study has limitations inherent to its retrospective nature and the use of aggregate data. The unit of analysis was each of the federal units. The quality of data was also limited by the efficiency of government agencies in collecting and providing precise and comprehensive information. However, the large number of procedures analyzed (≥ 3,300) in a country with continental dimensions and > 200 million inhabitants seems to make the findings robust and reliable. Pereira et al20 evaluated approximately 57,000 brain surgeries in the public health care system and found similar results to ours.

In conclusion, this study suggests that an overall lack of quality and major regional disparities exist in the surgical treatment of PC in the Brazilian public health care system. These inequities seem to be influenced by economic and demographic factors. Regional strategies and public health policies are urgently needed to improve care for PC in the Brazilian public health care system.

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AUTHOR CONTRIBUTIONS
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Financial support: Lucas V. dos Santos
Administrative support: Lucas V. dos Santos, Gilberto L. Lopes
 Provision of study materials or patients: Lucas V. dos Santos
Collection and assembly of data: Lucas V. dos Santos
Data analysis and interpretation: All authors
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Table 4 – Relationship between Length of Stay and Number of Procedures, GDP Per Capita, and Population

| Region and State | North Region | Acre | Roraima | Amagui | Amapá | Maranhão | Ceará | Parába | Alegrias | Bahia | Central-West Region | Mato Grosso | Southeast Region | Espírito Santo | São Paulo | Santa Catarina | São Paulo |
|------------------|-------------|------|---------|--------|-------|----------|------|-------|----------|------|---------------------|-------------|-----------------|-------------|-----------|--------------|-----------|
| Length of Stay (days) | 5.7 | 7.7 | 5.7 | 8.2 | 7.9 | 10.3 | 10.4 | 10.6 | 11.6 | 9.7 | 10.2 | 10.3 | 10.7 | 10.1 | 10.5 | 10.5 |
| GDP per capita (US$) | 5,800 | 5,200 | 5,900 | 5,100 | 5,500 | 5,300 | 5,200 | 5,000 | 5,100 | 5,400 | 5,500 | 5,300 | 5,100 | 5,200 | 5,300 | 5,400 |
| Population (1,000) | 5,000 | 5,200 | 5,400 | 5,100 | 5,500 | 5,300 | 5,200 | 5,000 | 5,100 | 5,400 | 5,500 | 5,300 | 5,100 | 5,200 | 5,300 | 5,400 |

Univariable

| Coefficient (95% CI) | P       |
|----------------------|---------|
| No. of procedures    | -0.01 (-0.05 to 0.03) | .581 |
| GDP per capita       | 0.07 (-0.11 to 0.24) | .466 |
| Population           | -0.04 (-0.14 to 0.06) | .414 |

Multivariable

| Coefficient (95% CI) | P       |
|----------------------|---------|
| No. of procedures    | 0.04 (-0.12 to 0.21) | .593 |
| GDP per capita       | 0.12 (-0.11 to 0.34) | .301 |
| Population           | -0.2 (-0.64 to 0.24) | .376 |

Abbreviation: GDP, gross domestic product.
AUTHORS’ DISCLOSURES OF POTENTIAL CONFLICTS OF INTEREST

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Lucas V. dos Santos
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