

Study of the evolution and variability of nontraumatic orthopedic surgeries in Brazil—9 years of follow-up

A database study

Alexandre de Paiva Luciano, MD, MSc^{a,*}, Tábata Cristina do Carmo Almeida, MSc^a, Francisco Winter dos Santos Figueiredo, PhD^a, Jean Henri Maselli Schoueri, MD^a, Luiz Carlos de Abreu, PhD^b, Fernando Adami, PhD^a

Abstract

In Brazil, there are no epidemiological statistics that map nontraumatic orthopedic injuries, their rate of variability, distribution by specialty, fatality rate, and the economic impact that these lesions and their consequences can bring to the country. The objective of this study was to evaluate the rates of variability for skills, deaths, mortality, and the economic impact of nontraumatic orthopedic surgeries in Brazil from 2008 to 2016.

This is a descriptive study conducted through the analysis of data relating to the indicators of hospital production regarding orthopedic procedures of the Department of Informatics of the Unified Health System (Departamento de Informática do Sistema Único de Saúde—DATASUS) between 2008 and 2016. The level of significance was 5%.

There was a predominance of hospitalizations for surgery of the lower limbs, which also resulted in the largest number of deaths. The surgical mortality rate recorded for the hip also needs to be considered. In general, there is a national increase in the number of orthopedic surgeries performed, accompanied by a concomitant increase in the number of deaths and mortality of the population exposed.

We observed a growing demand for hospitalization with a consequent increase in lethality and deaths. We can conclude that between 2008 and 2016, the number of hospitalizations for elective nontraumatic orthopedic surgical procedures increased significantly, driven mainly by lower limb surgeries, along with the cost of the *Unified Health System (Sistema Único de Saúde—SUS)* for these surgeries.

Abbreviations: AIH = Hospital Admissions Authorizations (Autorização de Internação Hospitalar), APC = annual percentage change, DATASUS = Department of Informatics of the Brazilian National Health System (Departamento de Informática do Sistema Único de Saúde), OA = osteoarthritis, SIH/SUS = Information System on Hospital Production (Sistema de Informação Hospitalar), SUS = unified health system (Sistema Único de Saúde), TABNET = health information database (Tabulador de informação de saúde), THA = total hip arthroplasty, TKA = total knee arthroplasty, WHO = World Health Organization.

Keywords: Brazil, lower limb, orthopedics, surgery, upper limb

Editor: Giovanni Tarantino.

Declarations

Ethics and consent to participate: No primary data will be collected hence approval ethics was not necessary.

License to publish: Completed and sent a copy of the Open Access-License to Publish (LTP).

Competing interests: The authors declare that they have no competing interests.

The authors have no conflicts of interest to disclose.

^a Epidemiology and Data Analysis Laboratory, Faculdade de Medicina do ABC (ABC Medical School), ^b Laboratório de Delineamento de Estudos e Escrita Científica, Faculdade de Medicina do ABC (ABC Medical School), Lauro Gomes Avenue Santo André/São Paulo, Brazil.

* Correspondence: Alexandre de Paiva Luciano, Epidemiology and Data Analysis Laboratory, Faculdade de Medicina do ABC (ABC Medical School) Lauro Gomes Avenue 2000, 09060-870, Santo André/SP, Brazil (e-mail: paivaortopedia@gmail.com).

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Medicine (2018) 97:21(e10703)

Received: 1 September 2017 / Accepted: 19 April 2018

<http://dx.doi.org/10.1097/MD.00000000000010703>

1. Introduction

The World Health Organization (WHO) has made the quest to fight physical inactivity one of its aims for this quarter century.^[1] Meanwhile, obesity remains a major public health problem worldwide.^[2] Being overweight or obese may contribute to the onset of nontraumatic injuries and influence the epidemiological rates of those diseases.^[3]

Musculoskeletal disorders as a cause of mortality and morbidity have been recognized by the World Health Organization (WHO).^[4,5] Nontraumatic musculoskeletal conditions occur equally or more frequently than other nontransmissible chronic medical conditions in people of all ages, especially between 65 and 74 years of age.^[6]

In general, nontraumatic musculoskeletal disorders require increasing medical and surgical interventions, and consequently, higher public and private costs.^[7] To prevent spending and reduce the number of people with severe injuries requiring surgery, it is important that public policies be based on evidence. Such evidence may direct health promotion and health service management actions to reduce morbidity, lethality, and the economic impact of orthopedic surgeries.^[8]

Unlike traumatic injuries that are the subject of publications,^[9,10] there are no epidemiological statistics that describe the

surgery rates for the treatment of nontraumatic orthopedic injuries in Brazil or the economic impact of these injuries.

Therefore, the aim of the present study was to evaluate the variability of rates and costs of nontraumatic orthopedic procedures performed by the *Unified Health System (Sistema Único de Saúde—SUS)* in Brazil between 2008 and 2016.

2. Methods

2.1. Study design

A descriptive study was carried out through the analysis of secondary data between 2008 and 2016. The data refer to hospital production indicators related to orthopedic surgeries and were obtained from the Department of Informatics of the Brazilian National Health System (Departamento de Informática do Sistema Único de Saúde—DATASUS). No primary data will be collected hence approval ethics was not necessary.

2.2. Data source

The data on hospital admissions to perform orthopedic surgeries were collected in 2017 DATASUS, where the Information System on Hospital Production (Sistema de Informação Hospitalar—SIH/SUS) was accessed. DATASUS keeps a free access database to update the health information systems of the country, integrate data, and assist in the management of the various health care levels.

Data on deaths, morbidity, disability, access to services, quality of care, living conditions, environmental factors, health care, hospital and outpatient network, demographic, and socioeconomic information are available through specific information systems.^[11]

The administrative health data in the country include the Hospital Information System of the Unified Health System (SIH/SUS), whose origins are in the Hospital Admissions Authorizations (Autorização de Internação Hospitalar—AIH), which contains the same data available in medical records. The AIH are

intended for the payment of admissions to public and private hospitals that belong to SUS. The AIH has the advantage of providing diagnostic, demographic and geographical information for each hospitalization.^[12]

The SIH/SUS coverage ranges from 70% to 80% of the Brazilian population. The main flaws of this system are related to the completion of the AIH and notification forms. For these reasons, data from the SIH/SUS require a period of approximately 2 years to be consolidated.^[13]

2.3. Data gathering

To access AIH data related to orthopedic surgical specialties, the following steps were performed within the DATASUS system, as described in Figure 1, which addresses the Stages of Data Gathering from the DATASUS across health information database (Tabulador de informação de saúde—TABNET) regarding musculoskeletal surgery (orthopedics).

2.4. Study variables

We selected variables related to surgical procedures in orthopedics, except for trauma surgeries, according to the group of surgical procedures (04) and subgroups of surgical procedures of the musculoskeletal system (0408), with the respective identification codes for organization in the system including: scapular waist surgery (040801), surgery of upper limbs (040802), surgery of vertebral column (040803), surgery of pelvic girdle (040804), surgery of lower limbs (040805), and general surgery (040806).

Orthopedic surgeries are divided into 6 groups, as mentioned above, and represent a grouping of surgical procedures as outlined below:

1. Reference 040801: includes 22 surgical procedures related to the shoulder girdle (shoulder);
2. Reference 040802: covers 63 surgical procedures related to the elbow, wrist and hand (upper limbs);
3. Reference 040803: grouping of 89 surgical procedures related to the spine and rib cage;

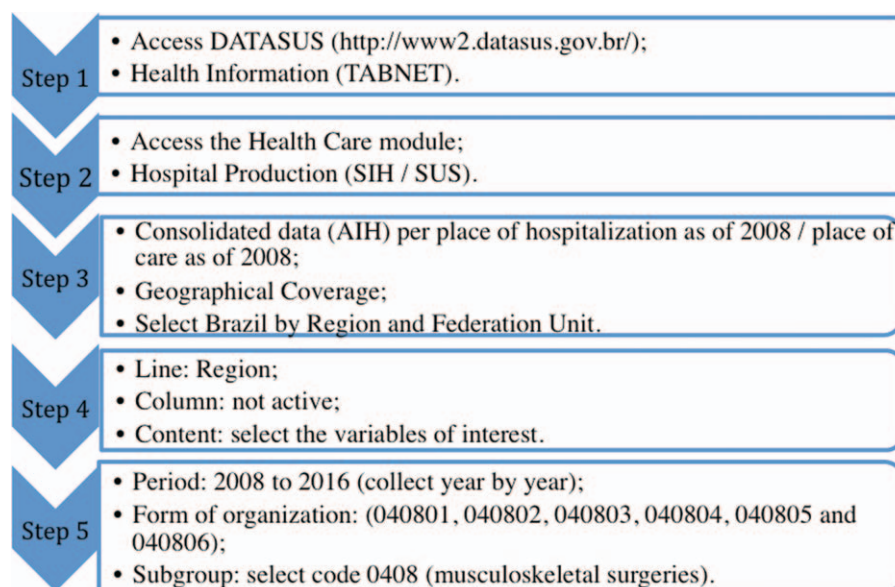


Figure 1. Flowchart of following steps performed within the DATASUS system. DATASUS=Department of Informatics of the Brazilian National Health System (Departamento de Informática do Sistema Único de Saúde).

Table 1**Variables collected in the SIH/SUS system related to hospital admissions for surgical procedures.**

| Variable | Description |
|--------------------------|---|
| AIH approved | Amount of AIH approved in the period of both new admissions and length of stay (long stay) |
| Total value spent | Value referring to the AIH approved in the period. This should be regarded as the approved amount of production |
| Average value of AIH | Total Value divided by the amount of AIH approved |
| days of stay | Total days of hospitalization, referring to AIH approved in the period. Days between hospitalization and discharge must be considered |
| Average stay | Average length of hospitalization for approved AIH |
| deaths | Number of hospitalizations that were discharged by death in the AIH-approved period |
| Surgery mortality rate * | Ratio between the number of deaths and the number of AIH-approved hospitalizations in the period, multiplied by 100 |

AIH=Hospital Admissions Authorizations (Autorização de Internação Hospitalar), SIH/SUS=Information System on Hospital Production (Sistema de Informação Hospitalar).

*The indicator is provided by the system as a surgical mortality rate, but it can be understood as an indicator of surgical lethality given its method of calculation.

- Reference 040804: includes 33 surgical procedures related to the pelvic girdle (hip)
- Reference 040805: includes 91 surgical procedures concerning the knee, ankle and foot (lower limbs);
- Reference 040806: includes 67 general orthopedic procedures (e.g., resection of bone tumors, myotendinic stretching, muscle reinsertion, osteosynthesis withdrawal).

2.5. Studied variables

Variables related to the number of surgeries and deaths were considered, as well as general and average costs by specialty and surgical mortality rate. The collected variables related to these hospital admissions for surgery in the field of orthopedics are presented in Table 1. After searching the DATASUS, we analyzed all the variables found.

2.6. Data analysis

To describe the distribution of hospital admissions, we used the absolute and relative frequency of hospital admissions and deaths. Gross values of surgical lethality were described. To understand the variation of these outcomes in the period, we estimated the annual percentage change (APC) of hospital admissions and deaths. The APC was calculated by the ratio of the difference in the number of events between the last and the

first year studied, divided by the amount observed in the first year.^[14]

$$APC = \frac{\text{Amount of events in 2016} - \text{Amount of events in 2008}}{\text{Amount of events in 2008}} \times 100$$

Interquartile regressions were used having as endpoints: the number of deaths and hospital admissions, the absolute value of surgical mortality and the cost of the surgery period. The use of these regressions was based on nonadherence of the distribution of these data to the normal distribution, as evaluated by the Shapiro–Wilk test ($P < .05$).

The values of β (slope) and the respective confidence interval of 95%, r^2 (adjusted predictive capacity) and “ P -value” were estimated in the regression, where β was the median variation of the outcomes in relation to the years of the studied period and r^2 was the predictive ability of the model to explain the outcomes. The “ P -value” and the confidence intervals showed the statistical significance of the annual variation in the behavior of these indicators. The level of significance was 5%. The program used was Stata 11.0^[15]

3. Results

In Brazil, there were 6,284,318 hospitalizations related to elective nontraumatic orthopedic surgical procedures in individuals of all age groups between 2008 and 2016.

Figure 2 presents an overview of the national volume of orthopedic surgeries performed during the study period. In general, there was a national increase in the number of orthopedic surgeries performed (APC% 17.5%) ($r^2=0.92$) ($P < .001$), accompanied by an increase in the number of deaths (56,078) (APC% 43.1%) ($r^2=0.97$) ($P < .001$) and mean lethality (0.88) ($r^2=0.85$) ($P < .001$) in the exposed population.

Table 2 describes the distribution of surgeries, deaths, and lethality resulting from nontraumatic orthopedic surgical procedures performed in Brazil between 2008 and 2016.

The number of hospitalizations and deaths related to lower limb surgeries (2,244,416 hospitalizations and 40,430 deaths) is predominant, corresponding to 35.7% of the total surgeries performed and 72.1% of the deaths recorded in the period due to nontraumatic orthopedic surgeries. Another point worth mentioning is the surgical lethality recorded in hip surgery (Table 1); despite representing 4.2% of surgical hospitalizations, hip surgery had the highest mortality rate, approximately 2.7 deaths per 100 surgeries.

Regarding the variability of the hospitalizations in the period, shoulder surgeries showed the greatest annual percentage change

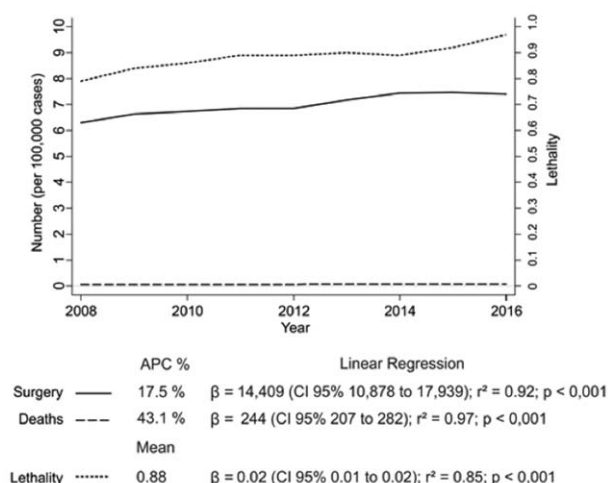


Figure 2. Description of orthopedics surgeries, deaths, and lethality during period 2008–2016.

Table 2

Distribution of surgeries, deaths and lethality resulting from elective nontraumatic orthopedic surgical procedures performed in Brazil between 2008 and 2016.

| Surgeries | Hospitalizations | %Hospitalizations | Deaths | %Deaths | Surgical lethality |
|----------------|------------------|-------------------|--------|---------|--------------------|
| Total | 6,284,318 | 100.0 | 56,078 | 100.0 | 0.89 |
| by Specialties | | | | | |
| Shoulder | 261,619 | 4.2 | 165 | 0.3 | 0.06 |
| Upper limb | 1,756,303 | 27.9 | 1,585 | 2.8 | 0.09 |
| Spine | 169,667 | 2.7 | 2,084 | 3.7 | 1.22 |
| Hip | 265,129 | 4.2 | 7,039 | 12.6 | 2.65 |
| Lower limb | 2,244,416 | 35.7 | 40,430 | 72.1 | 1.80 |
| Others | 1,587,184 | 25.3 | 4,775 | 8.5 | 0.30 |

(47.7% in the period, with an annual increase of 1355 surgeries, $P < .001$). In relation to deaths, a significant increase was observed in the number of deaths due to lower limb surgeries (46.1% in the period, with an annual increase of 175 deaths, $P = .01$) and in the number of deaths due to hip surgeries (41.2% in the period, with an annual increase of 26 deaths, $P < .001$) (Table 3).

Regarding the costs of elective nontraumatic orthopedic surgical procedures held in Brazil between 2008 and 2016, the country spent US\$ 179.1 million in 2008 and US\$ 261.7 million in 2016, an increase of 82.6 million over the period, with no statistically significant annual variation (Table 4).

Among procedures, although there was no significant increase in all grouped procedures, all of them individually increased, with

emphasis on the average cost of hip surgery, varying from 913.1 dollars in 2008 to 1120 dollars in 2016, with an increase of 519.2 dollars in the period and a significant annual growth of 33.9 dollars ($P = .006$).

4. Discussion

To our knowledge, this is the first study to present statistics of nontraumatic surgeries performed in the Unified Health System in Brazil, in which there was an increase in the rates and costs of surgeries in the period between 2008 and 2016. In addition, surgeries of the shoulder, hip, and lower limbs stood out in the period mainly in relation to admissions, deaths and surgical lethality, respectively.

Table 3

Annual variation in surgeries, deaths and lethality resulting from elective nontraumatic orthopedic surgical procedures performed in Brazil between 2008 and 2016.

| Surgeries | | | | | | |
|-------------|---------|---------|-------|-----------------------|-------|-------|
| Specialties | Period | | APC % | β (IC 95%) | r^2 | P^* |
| | 2008 | 2016 | | | | |
| Shoulder | 22,941 | 33,890 | 47.7 | 1,355 (943; 1,766) | 0.84 | <.001 |
| Upper limb | 178,931 | 200,981 | 12.3 | 2,467 (478; 4,456) | 0.51 | .02 |
| Spine | 18,154 | 18,542 | 2.1 | 141 (-66; 349) | 0.28 | .1 |
| Hip | 25,248 | 32,177 | 27.4 | 887 (504; 1,269) | 0.78 | .001 |
| Lower limb | 213,356 | 271,534 | 27.3 | 7,207 (4,230; 10,185) | 0.80 | .001 |
| Others | 171,419 | 183,187 | 6.9 | 1,884 (-39; 3,807) | 0.39 | .05 |

| Deaths | | | | | | |
|-------------|--------|-------|-------|------------------|-------|-------|
| Specialties | Period | | APC % | β (IC 95%) | r^2 | P^* |
| | 2008 | 2016 | | | | |
| Shoulder | 8 | 22 | 175 | 1 (-1; 4) | 0.20 | .26 |
| Upper Limb | 163 | 197 | 20.9 | 6 (-1; 13) | 0.50 | .07 |
| Spine | 197 | 251 | 27.4 | 4 (-4; 12) | 0.21 | .25 |
| Hip | 621 | 877 | 41.2 | 26 (8; 43) | 0.65 | .01 |
| Lower Limb | 3,576 | 5,223 | 46.1 | 175 (127; 223) | 0.81 | <.001 |
| Others | 475 | 643 | 35.4 | 15 (3; 26) | 0.46 | .02 |

| Surgical lethality | | | | | | |
|--------------------|--------|------|---------|-----------------------|-------|-------|
| Specialties | Period | | Average | β (IC 95%) | r^2 | P^* |
| | 2008 | 2016 | | | | |
| Shoulder | 0.03 | 0.06 | 0.06 | — | — | — |
| Upper limb | 0.09 | 0.10 | 0.09 | 0.003 (0.0003; 0.005) | 0.40 | .03 |
| Spine | 1.09 | 1.35 | 1.2 | 0.018 (-0.024; 0.60) | 0.14 | .34 |
| Hip | 2.46 | 2.73 | 2.65 | 0.023 (-0.059; 0.105) | 0.12 | .52 |
| Lower limb | 1.68 | 1.92 | 1.79 | 0.022 (0.005; 0.038) | 0.46 | .02 |
| Others | 0.28 | 0.35 | 0.3 | 0.005 (0.002; 0.008) | 0.38 | .004 |

APC = annual percentage change.

* Linear regression.

Table 4**Evaluation of the variation in costs resulting from elective nontraumatic orthopedic surgical procedures performed in Brazil between 2008 and 2016.****Total value in millions of American dollars (US\$) (3.0977)**

| Surgeries | Period | | Difference | β (IC 95%) | r^2 | P^* |
|----------------|--------|--------|------------|-------------------|-------|-------|
| | 2008 | 2016 | | | | |
| Total | 179.1 | 261.7 | 82.6 | 1.1 (-0.3; 2.5) | 0.03 | .13 |
| by specialties | | | | | | |
| Shoulder | 3.12 | 5.53 | 2.41 | 0.34 (0.24; 0.45) | 0.81 | <.001 |
| Upper limb | 23.35 | 30.45 | 7.1 | 0.92 (0.51; 1.33) | 0.71 | .001 |
| Spine | 30.2 | 40.48 | 10.28 | 1.7 (0.5; 2.9) | 0.54 | .01 |
| Hip | 23.05 | 36.04 | 12.99 | 1.9 (1.1; 2.7) | 0.75 | .001 |
| Lower limb | 79.29 | 124.79 | 45.5 | 6.3 (3.8; 8.7) | 0.82 | .001 |
| Others | 20.1 | 24.44 | 4.34 | 0.6 (0.1; 1.0) | 0.61 | .02 |

Average value in US\$

| Surgeries | Period | | Difference | β (IC 95%) | r^2 | P^* |
|----------------|--------|--------|------------|--------------------|-------|-------|
| | 2008 | 2016 | | | | |
| Total | 3332.8 | 4211 | 878.2 | 8.0 (-54.6; 70.6) | 0.01 | .8 |
| by Specialties | | | | | | |
| Shoulder | 136.1 | 163.2 | 27.1 | 3.9 (1.8;6.1) | 0.73 | .003 |
| Upper limb | 130.5 | 151.5 | 21 | 2.4 (1.2; 3.6) | 0.74 | .002 |
| Spine | 1664 | 2183.2 | 519.2 | 76.7 (29.3; 124.1) | 0.62 | .006 |
| Hip | 913.1 | 1120 | 206.9 | 33.9 (8.2; 59.7) | 0.63 | .02 |
| Lower limb | 371.6 | 459.6 | 88 | 12.6 (8.3; 16.9) | 0.77 | <.001 |
| Others | 117.3 | 133.5 | 16.2 | 2.9 (1.7; 4.0) | 0.67 | .001 |

* Linear regression.

We understand that by grouping several specific regions, the lack of stratification of orthopedic surgeries in the lower limbs may limit the results of this study. Other covariates data available, such as the hospital level and ownership, average length of in hospital stay and patient's socioeconomic status may also influence the rates of surgeries, deaths, surgical lethality, and costs of nontraumatic orthopedic surgeries. In addition, database limitations in relation to the coverage and quality of the data, besides the impossibility of some stratifications, should be considered as a limitation.

The rate increases found in this study can be explained by the increase in both the life expectancy of the population and the elderly population. As the world population continues to become larger and grow older, musculoskeletal disabilities have become the most common cause of elderly disability in developed countries.^[16] Bone and joint disorders account for more than half of all chronic diseases in people over 50 years old in developed countries, and they are also the most common cause of severe pain and disability long term.^[16,17]

In the United States, among 63.1 million people who reported chronic joint pain in 2012, knee pain was the most commonly cited, including 40 million people.^[6] In Brazil, nontraumatic orthopedic surgery and its subdivisions are underrepresented in the reviewed literature.

Orthopedic surgeries are the result of the clinical experience of surgeons and sources of scientific evidence for clinical decision making. More and more, these decisions are influenced not only by results and improvement of patients' quality of life but also by the financial implications that health decisions have among the often-competing stakeholders: the patient, surgeons, hospitals and the institutions that finance health care.

In the results, we observed that, apart from an increasing number of surgical procedures, the cost of surgery also increased significantly, especially for procedures carried out in the hip, spine, shoulders and legs.

Data from Brazilian patients showed that osteoarthritis (OA) was the main indication for surgical procedures, and hypertension was the most prevalent comorbidity among patients.^[18] The increase in life expectancy and the obesity epidemic are some of the risk factors for knee OA, and indications for total knee arthroplasty (TKA) have increased rapidly.^[6,16] Nearly 500,000 TKAs were performed in the United States in 2005 at a cost of more than US\$11 billion, and projections indicate an exponential growth in the use of TKAs over the next 2 decades.^[19]

In Brazil, where such estimates are scarce, the performance of these procedures has increased exponentially due to the evolution of the technique and the design of prostheses with good results.^[20] Increased mortality in relation to the hip surgery in this study corroborates a global concern regarding mortality related to hip surgery.^[21,22]

Hospitals and surgical procedures in the hip joint that have been associated with lower mortality rates and/or complications are typically performed in hospitals with a larger volume of patients with specific complex medical conditions.^[23]

Therefore, although studies recommend concentrating total hip arthroplasty (THA) in high-volume reference centers to reduce mortality and morbidity,^[21,23] the efforts to regionalize these procedures should take into account several factors, and more research is needed to identify aspects of the process in relation to patients, environmental care and costs to provide better results.

Regarding spinal surgery, nontraumatic pain in the spine may not be a potentially fatal condition, but it is an important public health problem in industrialized societies, and because of its high prevalence, spinal pain is a major cause of hospitalization.^[24]

It is estimated that more than 600,000 surgical interventions are performed each year on spinal patients in the United States, with an elevation in the rate of arthrodesis of 250% between 1990 and 2003.^[25] These intercontinental variations may reflect,

due to demographic differences among countries, the number of specialized centers, the decision of surgeons on the appropriate indications for spinal surgery, or patients with different thresholds for this type of surgical intervention.^[26,27]

In this research, we found shoulder joint surgery to result in the highest number of hospital admissions, showing a national increase of this pathology. Shoulder surgery has become a common procedure over the last 2 decades, especially with the evolution of arthroscopy and arthroplasties.^[28] As the number of shoulder procedures grows, the complications that lead to increased lethality and death have also grown, among which are infections,^[29] fatal air embolism,^[30] pneumothorax,^[31] pulmonary edema,^[32] and pneumomediastinum.^[33]

Nevertheless, it remains difficult to report the actual complication rate accurately, because most studies are case reports of isolated cases and, historically, there are low rates of complications associated with these procedures.^[34,35]

In Brazil, other important factors regarding surgery are the regional and social imbalances that make the discussion about the surgical indexes presented even more complex. Social ratio, per capita income distribution, and the distribution rate of elderly and young people in Brazil vary among states and regions.^[36]

There is increasing interest in the use of administrative data in health services and clinical research. Administrative databases can serve as useful and inexpensive resources access to large numbers of patients over expansive geographic regions with reliably reported data associated with accepted coding systems.^[37] The practical implications of studies involving databases is the first step to know the clinical profile of a large population with different social profiles and thus be able to implement public policies for prevention or treatment.

More research regarding the significant social and demographic differences existing in a country with continental dimensions such as Brazil is necessary for a better understanding of the distribution of nontraumatic orthopedic surgeries and their outcomes.

We can conclude that between 2008 and 2016, the number of hospitalizations for elective nontraumatic orthopedic surgical procedures increased significantly, driven mainly by lower limb surgeries, along with the costs of the *Unified Health System (SUS)* for these surgeries.

Acknowledgments

We thank the Technology and Services Research Company of the University of Taubaté (Empresa de Pesquisa Tecnologia e Serviços da Universidade de Taubaté—EPTS) for the support during this research.

Author contributions

Conceptualization: Alexandre Paiva Luciano, Tabata Cristina do Carmo Almeida, Fernando Adami.

Data curation: Alexandre Paiva Luciano, Tabata Cristina do Carmo Almeida, Francisco Winter dos Santos Figueiredo.

Methodology: Alexandre Paiva Luciano, Tabata Cristina do Carmo Almeida, Francisco Winter dos Santos Figueiredo.

Resources: Luiz Carlos Abreu.

Software: Francisco Winter dos Santos Figueiredo.

Supervision: Fernando Adami.

Visualization: Jean Henri Maselli Schoueri, Luiz Carlos Abreu.

Writing – original draft: Alexandre Paiva Luciano.

Writing – review & editing: Alexandre Paiva Luciano.

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