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Primary total knee arthroplasties under the Brazilian Public Health Unic System (SUS) - Number of procedures, regional distribution, hospitalization costs, average length of hospital stay and mortality (2012-2021)

Artroplastias primárias totais do joelho no âmbito do Sistema Único de Saúde (SUS) Público Brasileiro - Número de procedimentos, distribuição regional, custos de internação, tempo médio de internação e mortalidade (2012-2021)

Artroplastias primarias de reemplazo de rodilla en el Sistema Unificado de Salud (SUS) Público de Brasil - Número de procedimientos, regionalización, costos de hospital, tiempo promedio de internación y mortalidad (2012-2021)

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Glênio Minoru Naito
ORCID: https://orcid.org/0000-0001-7294-3276
Knee Surgery Group, Santa Izabel Hospital, Holy House of Mercy of Bahia, Brazil
E-mail: gmnaito@hotmail.com
Carlos Sidney Silva Pimentel
ORCID: https://orcid.org/0000-0001-7297-4953
Knee Surgery Group, Santa Izabel Hospital, Holy House of Mercy of Bahia, Brazil
E-mail: pimentel.css@gmail.com
Robson Rocha da Silva
ORCID: https://orcid.org/0000-0001-6902-9977
Knee Surgery Group, Santa Izabel Hospital, Holy House of Mercy of Bahia, Brazil
E-mail: robroc@superig.com.br
Aparecida Aguiar Lima Guedes
ORCID: https://orcid.org/0000-0002-7293-3358
School of Health Sciences and Welfare, Salvador University, Brazil
E-mail: pimentel.css@gmail.com
Alex Guedes
ORCID: https://orcid.org/0000-0001-7013-7107
Knee Surgery Group, Professor Edgard Santos Hospital University Complex, Federal University of Bahia, Brazil
Oncologic Orthopedics Group, Santa Izabel Hospital, Holy House of Mercy of Bahia, Brazil
E-mail: alexguedes2003@yahoo.com.br

Abstract
The aim of this study was to describe the number and regional distribution of hospital admission authorization (AIH), hospitalization costs, average length of stay (LOS), and mortality rates related to primary total knee arthroplasty (TKA) procedures funded by the Brazilian Public Health Unic System (SUS) from 2012 to 2021. A cross-sectional descriptive study on the number and regional distribution of AIH, hospitalization costs, average LOS, and mortality rates related to primary TKA procedures funded by the SUS from 2012 to 2021 was done. As results, 65,602 AIH were released in the evaluated period; in 2020 and 2021 there was a sharp decrease of procedures, probably due to the COVID-19 pandemic. The total value spent in the evaluated period was of 271,297,010.60 BRL. The average LOS was of 4.15 days. The absolute number of deaths was of 103, with 0.16% of mortality rate. It was concluded that the number and regional distribution of AIH was of 37,370 (57%) to the Southeast; 18,907 (29%) to the South, 5,250 (8%) to the Northeast; 2,758 (4%) to the Midwest and 1,317 (2%) to the North, totaling 65,602 admissions, with a total expenditure of 271,297,010.60 BRL (156,252,541.60 BRL in Southeast, 77,150,946.31 BRL in South, 21,194,955.07 BRL in Northeast, 12,077,393.69 BRL in Midwest and 4,621,173.96 BRL in North). The average LOS (in days) was of 4.15 (4.15 in Southeast; 3.83 in South; 4.6 in Northeast; 4.81 in Midwest; and, 5.71 in North). The mortality rate was of 0.16% (Southeast=0,14%; South=0,1%; Northeast=0,16%; Midwest=0,17%; and North=0,14%).
Keywords: Arthroplasty, Replacement, Knee; Hospital Costs; Length of stay; Mortality; Regional health planning.

Resumo
O objetivo deste estudo foi descrever o número e a distribuição regional da autorização de internação hospitalar (AIH), custos de internação, tempo médio de permanência (TMP) e taxas de mortalidade relacionadas aos

procedimentos de artroplastia do joelho (ATJ) primária financiados pelo Sistema Único de Saúde (SUS) Público Brasileiro de 2012 a 2021. Foi realizado estudo transversal descritivo sobre o número e a distribuição regional de AIH, custos de internação, TMP e taxas de mortalidade relacionadas aos procedimentos de ATJ primária financiados pelo SUS de 2012 a 2021. Como resultados, no período avaliado, foram liberados 65.602 AIH; em 2020 e 2021 houve uma redução acentuada dos procedimentos, provavelmente devido à pandemia COVID-19. O valor total gasto no período avaliado foi de R$ 271.297.010,60. O TMP foi de 4,15 dias. O número absoluto de óbitos foi de 103, com 0,16% da taxa de mortalidade. Concluiu-se que o número e a distribuição regional da AIH foi de 37.370 (57%) para o Sudeste; 18.907 (29%) para o Sul, 5.250 (8%) para o Nordeste; 2.758 (4%) para o Centro-Oeste e 1.317 (2%) para o Norte, totalizando 65.602 admissões, com um gasto total de R$ 271.297.010,60 (R$ 156.252.541,60 no Sudeste, R$ 77.150.946,31 no Sul, R$ 21.194.955,07 no Nordeste, R$ 12.077.393,69 no Centro-Oeste e R$ 4.621.173,96 no Norte). O TMP (em dias) foi de 4,15 (4,15 no Sudeste; 3,83 no Sul; 4,6 no Nordeste; 4,81 no Centro-Oeste; e 5,71 no Norte). A taxa de mortalidade foi de 0,16% (Sudeste=0,14%; Sul=0,1%; Nordeste=0,16%; Centro-Oeste=0,17%; e Norte=0,14%).
Palavras-chave: Artroplastia do joelho; Custos hospitalares; Tempo de internação; Mortalidade; Regionalização da saúde.

Resumen
El objetivo de este estudio fue describir el número y la distribución regional de la autorización de ingreso hospitalario (AIH), los costos de hospital, lo tiempo promedio de internación (TPI) y las tasas de mortalidad relacionadas con los procedimientos de artroplastia de reemplazo de rodilla (ARR) primaria financiados por el Sistema Unificado de Salud (SUS) Público Brasileño de 2012 a 2021. Se realizó un estudio descriptivo transversal sobre el número y la distribución regional de la AIH, los costos de hospitalización, lo TPI y las tasas de mortalidad relacionadas con los procedimientos de ARR primaria financiados por el SUS de 2012 a 2021. Como resultado, en el período evaluado, se liberaron 65.602 AIH; en 2020 y 2021 hubo una fuerte reducción en los procedimientos, probablemente debido a la pandemia de COVID-19. El monto total gastado en el período fue valorado en 271.297.010,60 reales. Lo TPI fue de 4,15 días. El número absoluto de muertes fue de 103, con un-0,16% de la tasa de mortalidad. Se concluyó que el número y la distribución regional de AIH fue de 37.370 (57%) para el Sureste; 18.907 (29%) para el Sur, 5.250 (8%) para el Noreste; 2.758 (4%) para el Medio Oeste y 1.317 (2%) para el Norte, totalizando 65.602 admisiones, con un gasto total de 271.297.010,60 reales (156.252.541,60 reales en el Sureste, R$ 77.150.946,31 reales en el Sur, 21.194.955,07 reales en el Noreste, 12.077.393,69 reales en el Medio Oeste y 4.621.173,96 reales en el Norte). Lo TPI (en días) fue de 4.15 (4.15 en el sureste; 3.83 en el sur; 4.6 en el noreste; 4.81 en el medio oeste; y 5.71 en el norte). La tasa de mortalidad fue de 0,16% (Sureste=0,14%; Sur=0,1%; Noreste=0,16%; Medio Oeste=0,17%; y Norte=0,14%).
Palabras clave: Artroplastia de reemplazo de rodilla; Costos de hospital; Mortalidad; Regionalización.

1. Introduction

Global population statistics show that the proportion of people aged >60 in 1950 was of 8%, up from 10% in 2000, and is expected to reach 21% in 2050 (Xu et al., 2008). Osteoarthritis (OA) is the most common joint disease (Chacur et al., 2017) and the condition that most results to disability, particularly in elderly population (Heidari, 2011). The incidence of OA increases significantly between the fourth and fifth decades of life (menopausal women and men aged 50 years), affecting 60% of people aged 65 years or older and 80% of those aged 75 years or older (Chacur et al., 2017). In Brazil, its prevalence is 16.9%, constituting motivation for 30 to 40% of all consultations in Rheumatology outpatient clinics and accounting for 7.5% of all medical licenses, being the fourth disease to determine retirement (6.2%) (Chacur et al., 2017).

Knee OA is a common condition that ails 12.1% or 27 million people in the United States (Lovald et al., 2013). That is a painful and crippling chronic disease that affects the entire joint, including articular cartilage, menisci, ligaments and periarticular musculature (Heidari, 2011). It has high prevalence rate compared with other types of OA on account of its presentation in certain groups, particularly younger obese women (Heidari, 2011). About 13% of women and 10% of men aged 60 years and older present symptomatic knee OA (Heidari, 2011; Kamaraj et al., 2020) and the number of people affected tends to increase due to population aging (Heidari, 2011; Lovald et al., 2014) and epidemic obesity (Heidari, 2011; Lovald et al., 2014; Kamaraj et al., 2020). Knee OA contributes to more than 27 billion USD in annual healthcare expenses in the Medicare patient population, with the expenditures related to total knee arthroplasty exceeding 11 billion USD annually (Malanga et al., 2020).

Knee OA treatment guidelines recommend physical therapy, nonsteroidal anti-inflammatory drugs, and tramadol (Malanga et al., 2020). Primary total knee arthroplasty (TKA) is the last resource in the treatment (Malanga et al., 2020; Soleimani et al., 2020), constituting a cost effective procedure that reliefs pain, (Xu et al., 2008; Lovald et al., 2013) fixes deformities (Xu et al., 2008) and promotes improvement in function (Xu et al., 2008; Lovald et al., 2013) and quality of life (Lovald et al., 2013) in 90% of the patients - 85% of them are satisfied with the surgery (Lovald et al., 2013). Since the geriatric population is expected to increase over the next decades, there will be an increase in the proportion of patients needing total knee arthroplasty (Xu et al., 2008). The incidence rate of TKA in the United States is the highest globally (Kamaraj et al., 2020), with more than 600,000 procedures carried out annually (Chikuda et al., 2013; Malanga et al., 2020) - this number is projected to increase to 1.5 million by 2030 (Sloan et al., 2018).

In recent years, we have observed a marked advance in the instrumental and implants used in the accomplishment of primary TKA, making these procedures more effective, reducing associated morbidity, and reducing the hospital length of stay (LOS) (Meyers et al., 1996; Featherall et al., 2019). These improvements, however, impact on the costs, which, together with the progressive increase in the volume of these procedures, impose a significant financial burden on the health system (Malanga et al., 2020; Soleimani et al., 2020) that can lead it to economic risk, making it very important to consider the necessary information to define appropriate strategies to cope with this reality.

The aim of this paper is to describe the number and regional distribution of hospital admission authorization (Autorização de Internação Hospitalar, AIH), hospitalization costs, average LOS, and mortality rates related to primary TKA funded by the Brazilian Public Health Unic System (Sistema Único de Saúde, SUS) during the years 2012 to 2021.

2. Methodology

A cross-sectional descriptive study was conducted on the number and regional distribution of AIH, hospitalization costs, average LOS, and mortality rates related to primary TKA funded by the SUS during the years 2012 to 2021. Secondary data were obtained from the hospital information system (Sistema de Informações Hospitalares, SIH) of the SUS (SIH/SUS), Brazilian Ministry of Health, in which cases of primary TKA were included, coded under the record 04.08.05.006-3 of the unified table of procedures, medications, orthotics, prostheses and synthesis materials management system (Sistema de Gerenciamento da Tabela Unificada de Procedimentos, Medicamentos, Órteses Próteses e Materiais de síntese, SIGTAP) of the SUS.

The number of hospitalizations was evaluated in all Brazilian Regions (Southeast, South. Northeast, North and Midwest). Population data for epidemiological coefficients calculation were obtained from the 2000 and 2010 censuses, carried out by the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística, IBGE).

For tabulation of data and statistical calculations, the Microsoft® Excel® program spreadsheet (2021 version) was used.

Due to the design of this study, it was not necessary to approve it in the Research Ethics Committee, because secondary information was used from the public domain database, in accordance with the Resolution 466/2012 of the National Health Council (Conselho Nacional de Saúde, CNS).

3. Results

In the evaluated period (2012-2021), 65,602 AIH encoded under the SIGTAP CODE 04.08.05.006-3 (primary TKA) were released by the SUS. The Southeast Region carried out approximately 57% (37,370) of all primary TKA, followed by the South Region, with 29% (18,907 procedures); the Northeast Region, with 8% (5,250 procedures); the Midwest Region, with

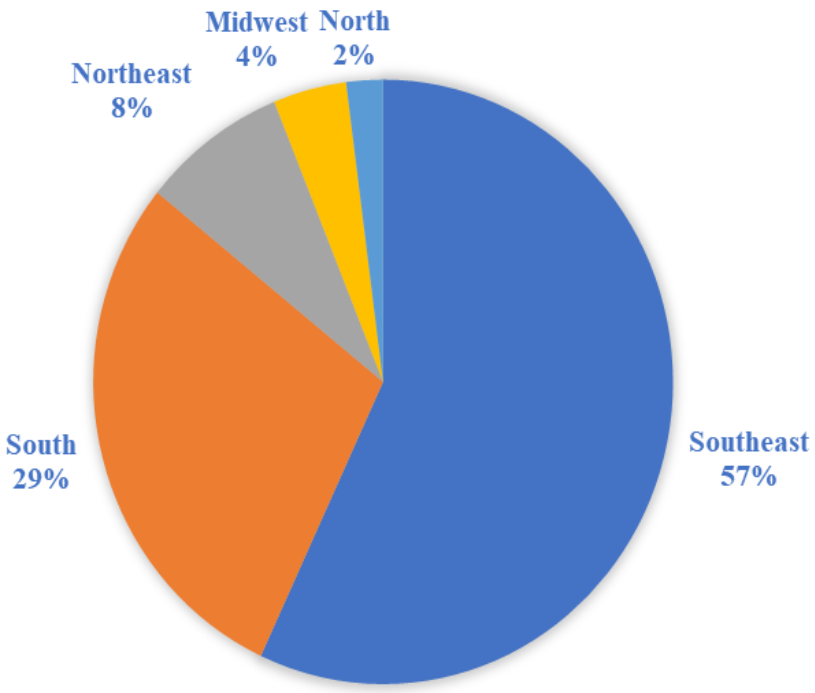
4% (2,758 procedures); and, the North Region, with 2% (1,317 procedures) (Table 1, Chart 1). The annual number of released AIH increased progressively in the evaluated decade, however, in the years 2020 and 2021 there was a sharp decrease in the number of procedures (Table 2, Chart 2), reaching, in 2020, a level of approximately 40,46% of the total amount spent in 2019 - the highest value in the evaluated decade (from 38,762,327.26 BRL in 2019 to 15,302,368.83 BRL in 2020) (Table 3).

The value spent by the SUS on primary TKA hospitalizations in the evaluated period was of 271,297,010.60 BRL (Table 3). The Southeast Region received approximately 57% (156,252,541.60 BRL) of all investment made in Brazil for this procedure in the appraised decade.

The average LOS (in days) for primary TKA funded by the SUS in the Brazilian Regions (2012 a 2021) is presented in Table 2. When we crossed-reference information regarding the number of released AIH (Table 1) with the number of daily LOS by year and Brazilian Regions, we found, in descending order, that in the North Region the average LOS was of 5.71 days; in the Midwest Region, it was of 4.81 days; 4.6 days in the Northeast Region; 4.15 days in the Southeast Region; and, 3.83 days in the South Region - the National average LOS in the evaluated period was of 4.15 days.

The absolute number of deaths occurred during hospitalizations due to primary TKA per region and year within the scope of SUS (2012-2021) was of 103 (Table 4). The National mortality rate in the assessed period was of approximately 0.16% (Table 5).

Chart 1. Distribution of Hospital Admission Authorizations (AIH) for primary TKA procedures by regions (2012-2021).



Source: Brazilian Ministry of Health – Hospital Information System (SIH) of Health Unic System (SUS).

Table 1. Number of released AIH by regions and years (2012-2021).

Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Southeast	3,374	3,886	4,004	4,074	4,433	4,435	3,864	5,064	2,139	2,097	37,370
South	1,783	1,994	2,215	2,036	1,972	2,002	2,431	2,508	986	980	18,907
Northeast	492	614	589	414	437	524	768	713	341	358	5,250
Midwest	182	249	222	249	271	386	404	456	146	193	2,758
North	143	191	173	221	139	148	117	105	46	34	1,317
Total	5,974	6,934	7,203	6,994	7,252	7,495	7,584	8,846	3,658	3,662	65,602

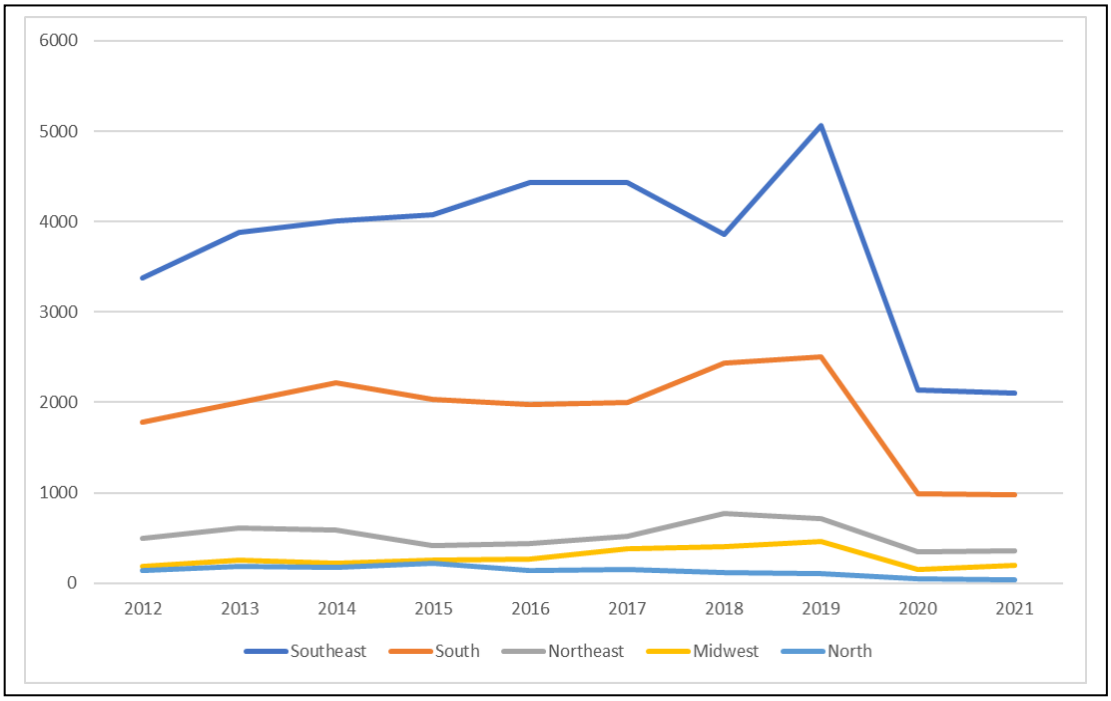
Source: Brazilian Ministry of Health – Hospital Information System (SIH) of Health Unic System (SUS).

Table 2. Length of stay (in days) for primary TKA funded by the SUS by regions and years (2012-2021).

Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Southeast	15,471	18,288	17,313	18,822	19,744	17,876	13,751	18,363	7,571	7,845	155,044
South	8,198	8,592	9,412	8,293	7,614	7,545	8,485	8,534	3,058	2,663	72,394
Northeast	2,582	2,925	2,818	1,835	2,016	2,511	3,248	3,471	1,412	1,355	24,173
Midwest	1,366	1,497	1,143	1,237	1,231	1,548	1,916	2,012	569	760	13,279
North	845	986	945	1,225	739	840	734	749	246	212	7,521
Total	28,462	32,288	31,631	31,412	31,344	30,320	28,134	33,129	12,856	12,835	272,411

Source: Brazilian Ministry of Health – Hospital Information System (SIH) of Health Unic System (SUS).

Chart 2. Timelines of Hospital Admission Authorization (AIH) for primary TKA procedures by regions (2012-2021).



Source: Brazilian Ministry of Health – Hospital Information System (SIH) of Health Unic System (SUS).

Table 3. Hospitalization values spent (in BRL) for primary TKA funded by the SUS by regions and years (2012-2021).

Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Southeast	12,536,316.36	15,791,943.74	16,368,510.65	18,029,122.84	17,635,341.49	18,387,256.93	17,214,009.24	22,506,963.78	8,913,927.03	8,869,149.54	156,252,541.60
South	6,594,310.60	8,161,233.94	9,117,574.29	8,270,606.77	7,744,407.33	7,891,538.82	10,256,001.06	10,733,664.04	4,120,012.82	4,261,596.64	77,150,946.31
Northeast	1,845,499.12	2,477,301.53	2,233,584.22	1,610,858.53	1,797,317.28	2,199,769.13	3,154,987.98	2,944,623.64	1,406,238.25	1,524,775.39	21,194,955.07
Midwest	671,871.79	1,016,629.34	1,005,654.79	1,145,156.64	1,067,544.17	1,643,465.15	1,759,873.40	2,144,758.50	690,241.08	932,198.83	12,077,393.69
North	375,074.22	661,670.88	626,176.58	824,366.03	389,737.10	521,063.46	524,416.94	432,317.30	171,949.65	94,401.80	4,621,173.96
Total	22,023,072.09	28,108,779.43	29,351,500.53	29,880,110.81	28,634,347.37	30,643,093.49	32,909,288.62	38,762,327.26	15,302,368.83	15,682,122.20	271,297,010.60

Source: Brazilian Ministry of Health – Hospital Information System (SIH) of Health Unic System (SUS).

Table 4. Absolute number of deaths during primary TKA hospitalizations by regions and years within the scope of SUS (2012-2021).

Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Southeast	-	-	-	1	1	-					2
South	-	-	3	-	1	-		1			5
Northeast	5	8	12	8	6	8	5	6	2	1	61
Midwest	5	3	6	2	2	3	4	4	1	1	31
North	3	-	-	-	-	-					3
Total	13	11	21	11	10	11	9	11	3	2	103

Source: Brazilian Ministry of Health – Hospital Information System (SIH) of Health Unic System (SUS).

Table 5. Mortality rates secondary to primary TKA procedures by regions and years within the scope of SUS (2012-2021).

Region	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
Southeast	-	-	-	0,45	0,72	-	-	-	-	-	0,14
South	-	-	0,51	-	0,23	-	-	0,14	-	-	0,1
Northeast	0,15	0,21	0,3	0,2	0,14	0,18	0,13	0,12	0,09	0,05	0,16
Midwest	0,28	0,15	0,27	0,1	0,1	0,15	0,16	0,16	0,1	0,1	0,17
North	1,65	-	-	-	-	-	-	-	-	-	0,14
Total	0,22	0,16	0,29	0,16	0,14	0,15	0,12	0,12	0,08	0,05	0,16

Source: Brazilian Ministry of Health – Hospital Information System (SIH) of Health Unic System (SUS).

4. Discussion

Our study seeks to describe the number and regional distribution of AIH, hospitalization costs, average LOS, and mortality rates related to primary TKA funded by the SUS during the years 2012 to 2021.

The number of primary TKA performed in the United States only in 2007 was >532,000 (Sloan et al., 2018; Fang et al., 2021). In 2014, 213 procedures were performed for every 100,000 inhabitants in that country (Carducci et al., 2020). In Brazil, between 2012 and 2021, 65,602 primary TKA funded by the Health Unic System (SUS) - whose access is public and free to the Brazilian population - were released. Among these procedures, more than half were performed in the Southeast Region, which has the highest number of inhabitants and the highest per capita income in Brazil. The relatively low number of procedures pointed out in our study in comparison with that found for the same procedures performed in the United States, is justified by the fact that we do not include data for primary TKA procedures funded by Brazilian private medical care network and health plans.

We observed that during the first two years in which the COVID-19 pandemic affected Brazil (2020-2021), there was a sharp decline in the number of released AIH for primary TKA that exceeded 50% in some Regions. This scenario was observed worldwide, reflecting the redefinition of the orthopedic care model about the invisibility of the threat and the lack of understanding about the SARS-CoV2 (Guedes, 2020). In some countries, at first, elective orthopedic surgical procedures have been suspended, returning to be carried out only through strict safety protocols from hospital admission to postoperative rehabilitation and clinical follow-up (Guedes, 2020). In Italy, one of the countries most impacted by the COVID-19 pandemic, the elective surgeries were suspended in February 23, 2020 (D'Angelo et al., 2020; Faldini, 2020; Ruggieri et al., 2020) In the United States, in mid-March 2020, the American College of Surgeons, considering the demand for preventable exposure of patients and professionals and the potential for consumption of health resources, recommended the pause of all elective procedures until the spread of the virus was contained (Jain et al., 2020; Couto et al., 2021). From 15 April 2020, the British Government determined that all elective surgical procedures were postponed or cancelled to mitigate the possible increase in demand for hospital beds because of critical care and allow the increase in the number of employees to contribute to the response to the pandemic (Baxter et al., 2020; Gonzi et al., 2020; Picardo et al., 2021; Stringer et al., 2021). In 2020, Chile (Barahona et al., 2021) recorded a reduction of about 64% in the number of primary TKA procedures corresponding to the elective orthopedic operation that suffered the most cuts during the evaluated period. Over time, in the face of the great pent-up demand, new safety protocols for elective surgeries are being instituted, restarting care for these patients (Guedes, 2020), but the absolute number of primary TKA procedures seems to have not yet reached the pre-pandemic volume.

In 2015, TKA and total hip arthroplasty (THA) procedures in United States incurred in 10.8 billion USD of "non-home" outlay (Yao et al., 2017), representing 6.3% of all Medicare expenditures (Carducci et al., 2020). In 2019, more than 11

billion USD was spent to perform primary TKA in that country (Chikuda et al., 2013; Malanga et al., 2020). In the evaluated decade (2012-2021), the Brazilian Government invested more than two hundred and seventy million reals for the SUS to finance primary TKA procedures.

Primary TKA is considered a high-cost procedure (Carducci et al., 2020) for health systems, justifying the search for strategies to reduce its associated expenditures. As the demand for primary TKA grows, there is a search for the gain in efficiency with which this intervention is carried out - even a modest reduction in cost per surgery or reduction in complication rate can translate into a substantial saving of overall healthcare costs (Lovald et al., 2014).

Given the increasing prevalence of THA and TKA procedures as well as the relative clinical homogeneity of these procedures, lower extremity joint replacement presents a major opportunity for cost savings (Yao et al., 2017). Payers, providers, and policymakers all have placed increased emphasis on strategies to control costs and improve quality associated with elective surgical procedures such as total joint arthroplasties (TJA) (Bozic et al., 2014). So-called value-based payment strategies, including episode-of-care or bundled payments (Bozic et al., 2014; Yao et al., 2017) have been proposed as a mechanism to improve quality and reduce costs of TJA by incentivizing greater communication and coordination among providers across the continuum of care (Bozic et al., 2014).

Implant prices were the primary contributors to total inpatient costs for all categories of total joint arthroplasty. Negotiating implant prices may result in substantially reduced hospital inpatient costs. Great private practice groups and specialized committees for medical-hospital negotiation would increase bargaining power and reduce the costs. Given the lack of cost transparency, however, is necessary further research to evaluate the efficiency of these strategies (Carducci et al., 2020).

Carducci et al. (2020), seeking to identify whether variation exists in total cost for different types of arthroplasties and to determine which cost parameters would direct this variation, found that implant prices were the most dispendious components of total cost across all types of joint arthroplasty, accounting for an average of 53.8% of these expenses. The primary TKA procedures funded by the SUS are paid in a bundled form, priced in a total of 4,302.63 BRL per hospitalization (values updated in March 2022), corresponding to four hospital nights in the hospital ward (hospital service) plus medical fees (professional service) (Table 6) and implant materials (Table 7). Up to two more days are admitted in the ward and any daily allowances in the intensive care unit (ICU) are financed separately. In a standard hospitalization, where there is no need to stay more days in the ward or stay in the ICU, the value of the implants corresponds to 73.2% of the total costs for performing a primary TKA.

Table 6. Hospital and professional service expenses for primary TKA procedures funded by the SUS (SIGTAP CODE 04.08.05.006-3). Updated values in March 2022.

Type of Service	**Amount paid per service**
Hospital Service (4 daily; maximum stay of up until more 2 daily is allowed, ICU daily are funded separately)	919.92 BRL
Professional Service	234.92 BRL
Total amount paid for hospitalization expenses	1,154.84 BRL

Source: Unified Table of Procedures, Medications, Orthotics, Prostheses and Synthesis Materials Management System (SIGTAP). Available at http://sigtap.datasus.gov.br/tabela-unificada/app/sec/inicio.jsp.

Table 7. Type of implant, SIGTAP CODE, maximum unit number per procedure and amount paid *per* unit of implants funded by the SUS for primary TKA procedures (SIGTAP CODE 04.08.05.006-3). Updated values for March 2022.

Type of Implant	**SIGTAP CODE**	**Maximum units number *per* procedure**	**Amount paid *per* unit**
Primary femural component (cemented/biological fixation)	07.02.03.022-8	1	1,671.60 BRL
Patellar component (cemented/biological fixation)	07.02.03.024-4	1	148.57 BRL
Primary tibial polyethylene component	07.02.03.027-9	1	352.96 BRL
Primary tibial metallic component (cemented/biological fixation)	07.02.03.028-7	1	854.48 BRL
Cement without antibiotics	07.02.03.138-0	2	60.59 BRL
Total amount paid for implants for a primary cemented TKA			3.148,79 BRL

Source: Unified Table of Procedures, Medications, Orthotics, Prostheses and Synthesis Materials Management System (SIGTAP). Available at http://sigtap.datasus.gov.br/tabela-unificada/app/sec/inicio.jsp.

Other two strategies for reducing inpatient costs of primary TKA are to shorten LOS and minimize perioperative and postoperative complications. In terms of LOS, there is a clear trend towards patient discharge as soon as safely possible. In the past years, average LOS after TKA in the United States has decreased from 9 to 4 days (Lovald et al., 2014).

Overall, implementation of clinical pathways has contributed to the widespread LOS reduction and complications after TKA (Xu et al., 2008; Lovald et al., 2014), including pain management protocols, early mobilization, aggressive rehabilitation, preventive interventions for postoperative complications, and patient education (Lovald et al., 2014).

Traditionally, the rationale to keep patients hospitalized after surgery has been driven by the risk of perioperative complications, decreased mobility, and difficulty in controlling pain. Recently, the search for decreasing LOS has moved some TKA procedures to an outpatient regimen by using minimally invasive surgery, regional anesthesia, and accelerated rehabilitation protocols. Some studies have shown that a decreased LOS or outpatient procedure through a clinical pathway system does not increase short-term complications and may even decrease complications in some instances (Lovald et al., 2014). The outpatient primary TKA presents a way to reduce potential costs such as postoperative personnel expenses. Outlays could be significantly reduced with lower LOS. The literature has shown that, with adequate patient selection, primary TKA is safe and effective in the outpatient regimen, minimizing possible medical complications, and may constitute an effective tool to reduce hospital costs (Carducci et al., 2020).

Lovald et al. (2014) estimated the costs, mortality and complications after TKA for differing LOS in the U.S. Medicare population. Compared to standard-stay (3-4 days) patients, there were sizeable cost reductions but an increased revision/readmission and mortality risk for the outpatient and short stay TKA groups. The shorter stay groups showed an improvement in associated diagnosed pain and stiffness compared to standard-stay patients, suggesting better early function. Patients who stayed or were obliged to stay in hospital for more than five days, had the highest costs and adjusted risks for mortality, revision, and many of the complications analyzed. Costs that can be attributed to knee osteoarthritis over a 2-year postoperative period were reduced by 1,967 USD per patient in the 1–2 day stay group and 8,527 USD per patient in the outpatient group but increased by 1,159 USD for the 5+ day stay group when compared to the 3–4-day (standard) stay group.

Therapies that allow patients to avoid surgery may help to reduce the overall healthcare costs. Intra-articular hyaluronic acid (AH) is a nonsurgical option that reduces pain, improves functionality, and may aid in delaying the time to knee arthroplasty (Malanga et al., 2020). Malanga et al. (2020) pointed out that patients with knee OA in the Medicare population, non-arthroplasty therapies and knee arthroplasty accounted for similar proportions of the treatment costs for knee

OA, with AH comprising a small fraction (5.6%) of the total knee OA–related costs. In their analysis, 23.7% of patients who received AH subsequently had knee arthroplasty during the study period. Of the patients who received AH and subsequently had knee arthroplasty, the AH injection resulted in only 1.8% of the overall knee OA treatment costs compared with knee arthroplasty, which contributed 76.6% of the knee OA–related cost.

On the other hand, in their systematic review, Kamaraj et al. (2020) compared the cost-effectiveness of primary TKA with non-operative treatment options. Primary TKA proved to be more economical, regardless of the factors related to patients, which could potentially influence decision-making policies, such as its Oxford Knee Score, risk for perioperative complications and body mass index, important findings to ensure that a more cost-effective treatment option is not denied to patients based on these metrics.

In our study, we found LOS less than 6 days for primary TKA in all Brazilian Regions, with an average of 4.15 days. The South Region had the lowest average LOS (3.83 days) and had the highest average of LOS (5.71 days) was found in the North Region. We observed that, in the National average, the LOS exceeded the world standard (3-4 nights), reaching almost 6 nights in the North Region, which coincides with the maximum LOS authorized by the SUS for this procedure.

Mantilla et al. (2002), in their series of 10,244 patients (4,775 male, 5,469 female) who underwent elective primary total hip or knee joint replacement surgery in a 10-year period, found that perioperative mortality was similar for male and female patients and was consistent across procedure types but increased significantly ($P< 0.001$) with older age. The frequency of death was less than 0.2% for patients aged less than 70 years, 0.4% for patients aged between 70 and 79 years, and 2.1% for patients aged 80 years or more. The median time to death was 9 days, with 30 of 47 (64%) events occurring within 14 days after the operation.

Xu et al. (2008), evaluating a cohort comprising 1663 knees in 1371 patients who underwent total knee arthroplasty in a 6-year period, found mortality rates <1%. They pointed out that with an increase in the number of same-day admissions, patients were optimized prior to surgery and the use of clinical pathways would also be probably associated with improvement in mortality rate compared to results from other centers.

Chikuda et al. (2013), using the Japanese Diagnosis Procedure Combination (DPC) Database, identified 41,060 patients submitted to primary TKA of which 27 (0.066%) died in-hospital, following surgery. Mortality and major complications after surgery were associated with advanced age, male gender, and increasing comorbidity.

Lovald et al. (2014) reported that the mortality related to primary TKA in the outpatient regimen was 0.2%. In the group with LOS of 1-2 days was 0.4%, in the group with LOS of 3-4 days was 0.3% and it was of 0.8% for LOS of five or more days of hospitalization. There was an increased (not statistically significant) adjusted risk for mortality in the short stay (1-2 days) group at 90 days. The authors pointed out that although primary TKA is a procedure of high cost and complexity, it seems to justify its indication regarding the reduction of mortality risk and serious complications development in the medium-term follow-up. They demonstrated that patients with knee OA who underwent TKA had a mortality risk that was approximately half that of the non-TKA group. There was also a reduction of new diagnoses of heart failure at 3, 5, and 7 years after surgery.

In our study, the mortality rate in the evaluated period (2012-2021) was 0.16%, with an absolute total number of 103 deaths, a percentage consistent with what was observed in the literature.

The limitations of the current study are in line with other retrospective studies database reviews. Most of them are related specifically to the unavailability of specific data concerning underlying knee pathologies, comorbidities and death causes. In addition, we deal with absolute numbers, which does not allow scrutinizing details regarding, for example, to specific expenses with prolonged hospital stay, ICU stay, among other aspects related to primary TKA hospitalizations.

5. Conclusion

The number and regional distribution of AIH for primary TKA procedures in the evaluated decade (2012-2021) was 37,370 (57%) to the Southeast Region, 18,907 (29%) to the South Region, 5,250 (8%) for the Northeast Region, 2,758 (4%) for the Midwest Region and 1,317 (2%) for the North Region, totaling 65,602 admissions.

Regarding hospitalization costs, we identified a total expenditure of 271,297,010.60 BRL by the SUS to carry out primary TKA procedures in the evaluated period. Of this total, 156,252,541.60 BRL were invested in the Southeast Region; 77,150,946.31 BRL in the South Region; 21,194,955.07 BRL in the Northeast Region; 12,077,393.69 BRL in the Midwest region; and 4,621,173.96 BRL in the North Region.

The National average LOS (in days) in the evaluated period was of 4.15 days. We found that the average LOS in the Southeast Region was 4.15 days; in the in the South Region, 3.83 days; 4.6 days in the Northeast Region; 4.81 days in the Midwest Region; and, 5.71 days in the North Region.

The total rate of deaths related to primary TKA funded by the SUS in the evaluated decade was of 0.16% (Southeast Region=0,14%; South Region=0,1%; Northeast Region=0,16%; Midwest Region=0,17%; and North Region=0,14%).

The findings presented in this study, particularly those related to the impact of the COVID-19 pandemic on the performance of primary TKA (a sharp decline in 2020-2021 that exceeded 50% in some Brazilian Regions), suggest the need to assess what happened in the evaluated period with other elective orthopedic procedures carried out under the SUS. Another aspect applies to the need for evaluation of the costs related to other total joint arthroplasties (number of procedures, regional distribution, hospitalization costs, mean length of hospital stay and mortality) like primary THA and primary total shoulder arthroplasty (TSA), considering the need of obtaining information to define appropriate strategies to cope with its economic impact on Brazilian public health system.

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