

Research Article

Trends in Reimbursement for All Billable Total Joint Replacement Procedures: An Analysis of the Medicare Part B Database from 2013-2021

Nithin Gupta, BS^{1a}, Morgan Turnow, DO^{2b}, Jagroop Doad, BS^{1c}, Forrest Dunivin, BS^{3d}, Emily Sydow, BS^{4e}, Tyler Williamson, DO^{5f}, Taylor Manes, DO^{2g}, Jia Bao Lin, DO^{2h}, Jignesh Patel, DO²ⁱ

- a Nithin Gupta is a fourth-year medical student at Campbell University School of Osteopathic Medicine in Lillington, NC. He will be applying for orthopedic surgery residency during the 2024-2025 match cycle. He is passionate about providing mentorship and teaching students to grow their network. He also has a strong interest in using research as a tool to advance orthopedic surgery and improve patient outcomes. His current research interests include spine, sports medicine, trauma, and reconstruction. Outside of medicine, he enjoys hiking, snowboarding, and watching all sports.

[Conflicts of Interest Statement for Nithin Gupta](#)

- b Morgan Turnow is a second year orthopedic surgery resident at OhioHealth Doctor's Hospital in Columbus, OH. She attended medical school at the University of Pikeville Kentucky College of Osteopathic Medicine. She is passionate about enhancing research and educational opportunities for medical students. Her current research interests include shoulder and elbow surgery, sports medicine, and education in orthopedics. Outside of medicine, she enjoys traveling, college football, and spending time with her pets.

[Visit Dr. Turnow's Website](#)

[Conflicts of Interest Statement for Dr. Turnow](#)

- c Jagroop Doad is an incoming fourth year medical student at Campbell University in North Carolina who has a strong interest in Internal Medicine, Cardiology, and Stroke.

[Connect with Jagroop Doad on LinkedIn](#)

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- d Forrest Dunivin was born and raised in Southern California. From a very early age, Forrest was heavily involved with athletics and had the opportunity to play football at the University of Washington. At UW, he completed my undergraduate degree studying physiology. He currently attends Kansas City University College of Osteopathic Medicine and is heavily interested in pursuing orthopedics. His extensive involvement with athletics has shaped his current research interests in orthopedic sports medicine. He is particularly passionate about advancing orthopedics through impactful sports medicine research development, focusing on athletic recovery timeline reduction and injury recurrence prevention. In his free time, he enjoys going to the gym, playing intramural sports, playing video games, exploring the outdoors, and spending time with his friends.

[Connect with Forrest Dunivin on LinkedIn](#)

[Conflicts of Interest Statement for Forrest Dunivin](#)

- e Emily Sydow is a 4th year osteopathic medical student and current undergraduate teaching fellow at the Kentucky College of Osteopathic Medicine. She hopes to become a pediatric orthopedic surgeon and help patients live to their fullest potential.

[Conflicts of Interest Statement for Emily Sydow](#)

- f Dr. Williamson is a second-year orthopaedic resident at University of Texas Health San Antonio with an interest in shoulder and elbow, joints, and sports.

[Visit Dr. Williamson's Website](#)

[Connect with Dr. Williamson on LinkedIn](#)

[Conflicts of Interest Statement for Dr. Williamson](#)

- g Taylor Manes is a second-year orthopedic surgery resident at OhioHealth Doctor's Hospital in Columbus, OH. He attended medical school at A.T. Still University Kirksville College of Osteopathic Medicine. He is passionate about providing mentorship and networking resources for medical students while taking a keen interest in furthering research in the orthopedic world. His current research interests include hand, sports medicine, and shoulder and elbow surgery. Outside of medicine, he enjoys spending time with his family and friends and loves to watch the Kansas City Chiefs win.

[Visit Dr. Manes's Website](#)

[Conflicts of Interest Statement for Dr. Manes](#)

- h Dr. Lin is currently a PGY-4 orthopedic resident at OhioHealth in Columbus Ohio. He is interested in pursuing a fellowship in spine.

[Conflicts of Interest Statement for Dr. Lin](#)

- i Dr. Jignesh Patel is board certified, and fellowship trained orthopedic surgeon with 17 years of experience in Columbus, Ohio. He is the Orthopedic Surgery Residency Program Director for OhioHealth and Adjunct Clinical Assistant Professor of Orthopedic Surgery at the Ohio University Heritage College of Osteopathic Medicine. He graduated from Wayne St. University, Detroit, MI with a bachelor's degrees in biology and history. He also received a master's degree in Biological Sciences. Dr. Patel went on to the Lake Erie College of Osteopathic Medicine for medical school. Medical school was followed by a residency in orthopedic surgery at Michigan State University-Pontiac Osteopathic Hospital. His training prepared him for a one-year fellowship in Adult Reconstruction at Desert

¹ Campbell University, ² Orthopedic Surgery, OhioHealth, ³ Kansas City University, ⁴ University of Pikeville, ⁵ Orthopedic Surgery, The University of Texas at San Antonio

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Introduction

Total joint arthroplasty (TJA) remains highly prevalent, nearly rivaling the prevalence of other challenging conditions such as heart failure. Annually, there are over 790,000 total knee replacements and more than 450,000 hip replacements performed in the United States. As the demand for TJAs steadily increases, issues related to access, and quality have become increasingly pronounced. Despite the significant annual rise in volume of surgeries, there exists a notable gap pertaining to the epidemiology and reimbursement rates of TJAs within the United States.

Methods

Publicly available data from the Centers for Medicare & Medicaid Services Database was extracted. The dataset was queried to retrieve information on all TJA procedures spanning the years 2013 to 2021. Demographic and reimbursement variables were also analyzed. Furthermore, a regional analysis was performed, categorizing the data based on the United States Census regions. All monetary values in the analyses were adjusted for inflation and statistical significance was indicated by $p < 0.05$.

Results

From 2013-2021 there was an overall significant increase in total beneficiaries coupled by a significant decrease in Medicare reimbursement over the same time period. Total shoulder arthroplasties had the greatest increase in beneficiaries (124.42%) and greatest decline in Medicare reimbursement (-51.23%). When stratified by region, the Northeast had the greatest mean Medicare reimbursement and the South had the greatest total beneficiaries, with reimbursement significantly declining across all regions.

Conclusion

With an aging United States population, the number of individuals requiring joint arthroplasty procedures is only expected to increase. The results of this study demonstrate an overall decline in reimbursement rates for TJAs coupled with increasing numbers of procedures. This may contribute to increasing strain on orthopedic surgeons and it is crucial to address the factors contributing to these trends. Future studies may seek to further clarify potential implications of this unsustainable trend and explore potential solutions.

Orthopedic Center, Las Vegas, Nevada. Dr. Patel has research interest in hip and knee replacement, orthopedic trauma, value-based science, and prevention of infection. He has publications in numerous peer-reviewed journals. Finally, he sits on the Editorial Board for the American Osteopathic Academy of Orthopedics, the Peer-Review Committee for OhioHealth, and the Surgical Clinical Guidance Committee for OhioHealth. Dr. Patel divides his time between the responsibilities as program director and clinical practice. He has a passion for mentorship of medical students and residents as well as educating patients and families regarding orthopedic treatment options and surgery.

In his free time, Dr. Patel enjoys spending time with his wife and two children. He also enjoys playing guitar and golf.

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INTRODUCTION

Total joint arthroplasty (TJA)¹ continues to be one of the most performed orthopedic procedures, providing a solution that enhances the quality of life for individuals suffering from age-related degenerative diseases such as osteoarthritis (Ritter et al. 1995; Jones et al. 2005; Tarakji et al. 2018). As the elderly population continues to grow, the increased requirement for joint replacements continues to place a large burden on hospital systems and healthcare providers (Administrator for Community Living 2021). In 2022, total hip and knee procedures alone accounted for 2.8 million procedures performed in the United States, reflecting a procedural volume growth of 14% compared to the previous year (Hegde et al. 2023). Medicare, covering more than 18% of the United States' population, stands as the primary payer for inpatient encounters (El-Nahal 2020). Given that Medicare reimbursements significantly contribute to a surgeon's income, the reimbursement rates have the potential to impede patient access to care by disincentivizing surgeons from performing certain procedures (Feng et al. 2020). The question of whether Medicare reimbursement for TJAs continues to be economically practical for surgeons remains. The goal of this study is to examine the temporal trends in Medicare reimbursement for all TJA procedures from 2013-2021, understand differences between procedure types, and compare regional reimbursement rates to gain insight into the potential impact of recent trends on future reimbursement dynamics.

METHODS

DATA SOURCE AND VARIABLES OF INTEREST

Data regarding joint replacements from 2013-2021 was collected from the Centers for Medicare & Medicaid Services Database, which provides information on provider utilization and payments for procedures by provider (Centers for Medicare & Medicaid Services Data, n.d.). To adjust monetary values for inflation, the Consumer Price Index was used as provided by the Bureau of Labor Statistics Database (U.S. Bureau of Labor Statistics, n.d.). For regional analysis, data obtained from the Medicare database was divided into

four regions based on the predefined Census Bureau regions (Northeast, Midwest, West, and South) ("Census Regions and Divisions of the United States," n.d.).

The Medicare database was queried using the following Healthcare Common Procedure Coding System (HCPCS) codes: 27130 (total hip arthroplasty), 27447 (total knee arthroplasty), 27702 (total ankle arthroplasty), 23472 (total shoulder arthroplasty), 24363 (total elbow arthroplasty), and 25446 (total wrist arthroplasty). These data were then extracted for the years 2013-2021 as available.

Demographic, provider utilization and reimbursement variables were collected from the filtered data. Demographic variables included location by state. Utilization and reimbursement variables included total beneficiaries, total services, total submitted charge, and total Medicare payment.

DATA ANALYSES

Monetary values including total submitted charge and total Medicare payment were adjusted for inflation such that all values were adjusted for 2021 inflation values. All statistical analyses were performed using adjusted monetary values. For comparison of beneficiaries and average adjusted reimbursement between 2013 and 2021, *Welch's t-test* was employed, with an adjusted *P-value* applied to correct for multiple comparisons. To assess the significance of temporal trends in reimbursement and beneficiaries by region, linear regression analysis was conducted. Analysis of variance, followed by Tukey's Post-Hoc test, was employed to identify significant differences between regions concerning reimbursement and beneficiaries. Adjusted *P-values*, correcting for multiple comparisons, were also computed for this analysis.

RESULTS

OVERALL MEDICARE REIMBURSEMENT FOR TOTAL JOINT REPLACEMENT PROCEDURES

The total number of beneficiaries in 2021 were TSA (70,525), THA (233,059), TKA (511,546), and TAA (767). The mean adjusted Medicare reimbursement for these pro-

¹ TJA: total joint arthroplasty, HCPCS: healthcare common procedural coding system, THA: total hip arthroplasty, TKA: total knee arthroplasty, TAA: total ankle arthroplasty, TSA: total shoulder arthroplasty, TEA: total elbow arthroplasty, TWA: total wrist arthroplasty, BPCI: Bundled Payments for Care Improvement, CMS: Centers for Medicare and Medicaid Services

cedures in 2021 was TSA (\$783.82), THA (\$839.17), TKA (\$881.40), and TAA (\$609.90). For TEA and TWA, the most recent data was for 2019 which indicated 23 and 11 total beneficiaries and an average reimbursement of \$1,842.68 and \$1,536.02, respectively.

When comparing the most recent 2021 mean payments to 2013 values, TSA (23472) had the greatest percent reduction (-51.23%) in reimbursements with all procedures significantly ($p<0.001$) declining in mean Medicare payment ([Table 1](#)). The percent change for both 2013 and 2021 were also examined regarding total beneficiaries with TSA demonstrating the greatest percent increase (124.42%, $p<0.001$). THA (27130) and TKA (27447) both also had significantly increased total beneficiaries ($p<0.01$), while TAA (27702) had an insignificant increase (34.09%, $p=0.627$) over the study period.

REGIONAL ANALYSIS OF TOTAL JOINT REPLACEMENT REIMBURSEMENT

The Northeast region had the greatest mean Medicare payment (\$1,731.09), while the South had the highest number of mean beneficiaries (60,224) for TJAs over the study period. For all regions, the mean Medicare payment for TJA decreased significantly from 2013-2021 ($p<0.05$), with the largest decrease per year seen within the Northeast region (\$-61.88 per year) ([Figure 1A-B](#)). For beneficiaries, all regions increased insignificantly, with the South having the largest increase per year (1,440, $p=0.723$). Mean adjusted submitted charge decreased significantly for all regions ($p<0.001$) across the study period ([Table 2](#)).

A regional analysis for mean Medicare payment, mean beneficiaries, or mean adjusted submitted charge per year, stratified by procedure type was also performed ([Figure 2A-C](#)). For TAAs, there was a significantly higher mean Medicare payment seen in the Northeast compared to the Midwest (\$1,367.88 vs. \$971.10, $p=0.02$). For TEAs, the Northeast had a significantly greater mean Medicare payment compared to the South (\$2,489.32 vs. \$1,734.69, $p=0.04$). There were no other significant differences in Medicare payment between any region for all other procedures.

Regarding mean beneficiaries per year ([Figure 2B](#)), the South had the greatest number for all procedure types. For TSA, THA, and TKA, there were significantly more mean beneficiaries per year in the South than all other regions (TSA: 21,227 $p<0.01$; THA: 72,572 $p<0.001$; and TKA: 106,229 $p<0.001$). The South exhibited the highest average number of beneficiaries for TAA (261), which was significantly greater than the Northeast and Midwest ($p<0.05$), but not the West ($p=0.269$). The Northeast region had the highest mean beneficiaries per year (14) for TEA, significantly greater than the Midwest ($p<0.05$). It was insignificant when compared to the South, and there was no analysis conducted for the West due to insufficient data. There was not enough data to perform an analysis for TWAs.

Finally, the Northeast region had a significantly greater mean adjusted submitted charge compared to all other regions for TAAs (\$18,477.97, $p<0.001$) and TKAs (\$10,591.91, $p<0.05$) ([Figure 2C](#)). In the Northeast, the highest submit-

ted charge for TSAs also was seen (\$10,172.63), which was significantly higher than both that of the South and the West ($p<0.01$). Similarly, for THAs, the submitted charge for the Northeast (\$11,914.96) was significantly higher than all regions except the Midwest ($p<0.01$).

DISCUSSION

As the elderly population of the United States continues to grow, the number of total joint replacement procedures is expected to rise (Shiels et al. 2021; Singh et al. 2019). In fact, THA and TKA procedures are expected to rise by 176% and 139% by 2040, respectively (Shichman et al. 2023). Even with an increase in the number of procedures, the literature has documented a significant decline in Medicare reimbursement to physicians in both surgical and non-surgical specialties (Pollock et al. 2020; Schartz and Young 2021). Consequently, this study sought to comprehensively evaluate the trends for various total joint replacement procedures. The results of this study demonstrate that there has been an overall significant decrease in Medicare reimbursement for all TJAs considering an increase seen in the number of beneficiaries, especially for TSAs. Moreover, notable regional variations are evident (Fisher et al. 2003), particularly in the Northeast where Medicare payment reductions surpass those in other regions.

Overall, we observed a nationwide decrease in the reimbursements for TJAs. This trend appears to stem from reduced costs associated with joint implant costs and a decrease in hospital expenditures for post-acute care (Navathe et al. 2018). When it comes to individuals receiving adequate medical care, accessibility plays a pivotal role. The geographical proximity between provider and individual is a major factor, as people cannot access care if facilities do not exist in their geographic area (National Academies of Sciences, Engineering, and Medicine et al. 2018). Increasing the number of healthcare providers in a geographical area has the potential to increase accessibility to care. Zmistowski et al explored this concept, finding that there was a 28.6% increase in the total number of surgeons performing more than 10 TSAs per year in the Medicare population. This surge in availability resulted in over 95% of the population being served within a 200-kilometer radius of each surgeon, aligning with our findings which showed a 124.42% increase in TSA beneficiaries (Zmistowski et al. 2018). The principles of supply and demand are evident in this context, as increased availability could be a contributing factor to the decline seen in procedure costs. Between 2011 and 2017, there was a notable 103.7% rise in primary shoulder arthroplasties (Wagner et al. 2020). Over the past years, operating time and surgical efficiency have increased, leading to potential drops in procedural rates and subsequent reimbursements (Testa et al. 2022).

Regarding hospital size and accessibility regarding joint care, in 2013, the Centers for Medicare and Medicaid Services (CMS) took a significant step by expanding the voluntary bundled payment nationwide through the Bundled Payments for Care Improvement (BPCI) initiative (Navathe

Table 1. Temporal change in reimbursement for TJA procedures adjusted for inflation and total change in TJA beneficiaries. TWA values were not included in this table as data was only available for 2019.

	Mean 2013 Adjusted Reimbursement (\$)	Mean 2021 Adjusted Reimbursement (\$)	% Change	<i>P-value</i>	Total 2013 Beneficiaries	Total 2021 Beneficiaries	% Change	<i>P-value</i>
THA: 27130	1,496.03	839.17	-44.04%	p<0.001	161,660	233,059	44.17%	p<0.001
TKA: 27447	1,643.03	881.40	-46.49%	p<0.001	373,050	411,546	10.32%	p=0.006
TSA: 23472	1,603.03	783.82	-51.23%	p<0.001	31,426	70,525	124.42%	p<0.001
TAA: 27702	1,183.47	609.90	-48.61%	p<0.001	572	767	34.09%	p=0.627
TEA: 24363	2,489.32	-	-	-	14	-	-	-
TWA: 25446	-	-	-	-	-	-	-	-

et al. 2018). The initiative aimed to streamline payments for patients, particularly focusing on major joint replacement of the lower extremity, where hospitals bundled hospitalizations and incorporated up to ninety days of post-acute care into their payment structures (CMS.gov 2021). Following reports of financial savings with BPCI, CMS introduced the Comprehensive Care for Joint Replacement Model in 2016. This model mandated hospitals to bundle joint replacement procedures, aiming to enhance efficiency and quality of care delivery (Centers for Medicare and Medicaid Services 2015). However, this model has faced criticism for its potential to place an unfair financial burden on hospitals, particularly for care provided outside the hospital setting. This criticism is especially important for hospitals with low-procedure volume, as it could deter them from performing the necessary procedures and ultimately hinder patient access to essential care services (Ibrahim, Kim, and McConnell 2016). As we move forward, the ongoing assessment of insurance and governmental policies will be necessary, given the dynamic nature of our population and the diverse needs of rural and urban areas. Furthermore, addressing specific regional trends will be essential to ameliorate patient care and outcomes.

In general, the Northeast region consistently saw the highest procedural costs in the United States, primarily influenced by the elevated cost of living and the Medicare Geographic Practice Cost Index (Committee on Geographic Adjustment Factors in Medicare Payment et al. 2011). The index is an integral component of the Medicare payment system for physicians, used to adjust the relative value units of services (Seidenwurm and Burleson 2014). In the calculation of Medicare reimbursement rates, factors such as physician work, practice expenses, and liability expenses are considered ("RBRVS Overview" 2024). Once the relative values have been determined, they are adjusted to ensure Medicare does not overpay or underpay by region (Committee on Geographic Adjustment Factors in Medicare Payment et al. 2011). These intertwined factors contribute to a scenario where medical procedures, treatments, and healthcare services command higher prices in comparison to other regions. The cost of living directly impacts healthcare expenses, shaping the pricing structure for procedures. Upon regional data analysis, we observed a noticeable difference in reimbursement rates with the Northeast region registering the highest average of \$1,731.09. When comparing the four regions, there was a notable distinction in the standard cost of living, with 60% of the top 10 states with the highest cost of living situated in the Northeast (Rothstein 2024). Consequently, individuals and healthcare providers in this region face unique challenges arising from the complex interplay of these factors, prompting ongoing discussions and initiatives aimed at addressing healthcare affordability and accessibility in the Northeast.

LIMITATIONS

Although this study sought to thoroughly examine trends in Medicare reimbursement for various total joint replacement procedures it is not without limitations. This study relied solely on HCPCS codes, data may be subject to inac-

curacies due to data entry with coding or billing. However, it has been shown that the CMS is relatively accurate thus these mistakes are expected to be minimal. Additionally, by utilizing Medicare data this study did not evaluate trends in payment billed to patients with private insurance. As it has been reported, private insurance reimburses physicians at a higher rate, hence the trends presented in our study may not accurately represent payment for physicians primarily billing solely to private insurance. It is important to note that there was incomplete or minimal data regarding TEA and TWA rendering it difficult to draw conclusions for these procedures. Finally, although most joint replacement procedures are indicated for elderly patients secondary to pathologies such as osteoarthritis, there may be a subset of those under 65 years of age who would not be included in the CMS database, and thus not included in the results of our study.

CONCLUSION

The projected increase in the United States' elderly population has created a rapidly growing need for various total joint replacement procedures, putting a rising demand on orthopedic surgeons. There is a clear decline in reimbursement rates across all included total joint procedures however the number of beneficiaries has only increased. This trend is also demonstrated across all regions of the United States with the most notable overall decrease seen in reimbursement within the Northeast region. Future studies should seek to understand the effect of these trends on orthopedic surgeons both individually and as a profession. Further, by identifying contributing factors to these trends, actionable measures may be taken to allow fair compensation for orthopedic surgeons as demand rises.

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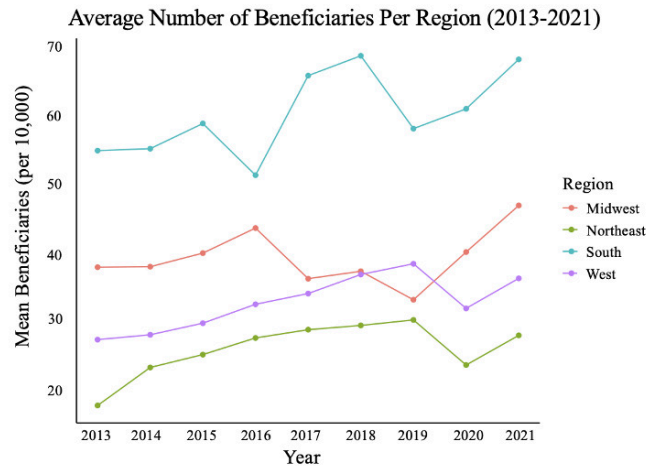


Figure 1A. Line graph depicting temporal trends in the average number of beneficiaries per region.

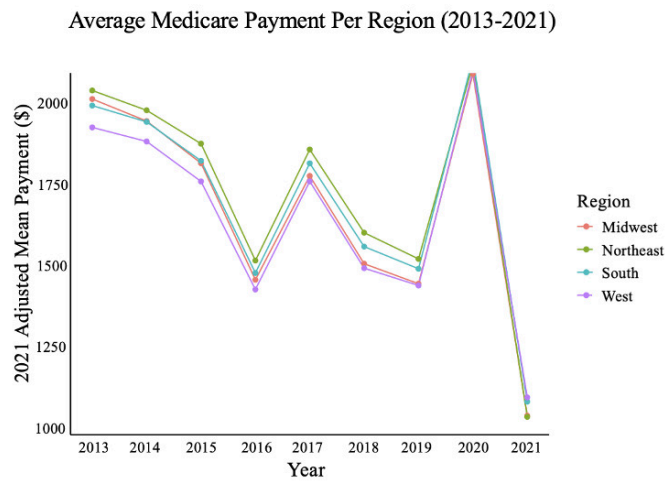


Figure 1B. Line graph depicting the average Medicare payment per region by region.

Table 2. Analysis of temporal trends by region in TJA procedures

Region	Change per Year (Payment)	P-value	Change per Year (Beneficiaries)	P-value	Change per Year (Submitted Charge)	P-value
Midwest	-44.09	0.041	266.39	0.9215	-301.11	<0.001
Northeast	-61.88	0.002	973.87	0.5509	-216.40	<0.001
South	-51.33	0.005	1,440.19	0.7237	-190.73	<0.001
West	-51.30	0.002	1,155.19	0.5668	-114.67	<0.001

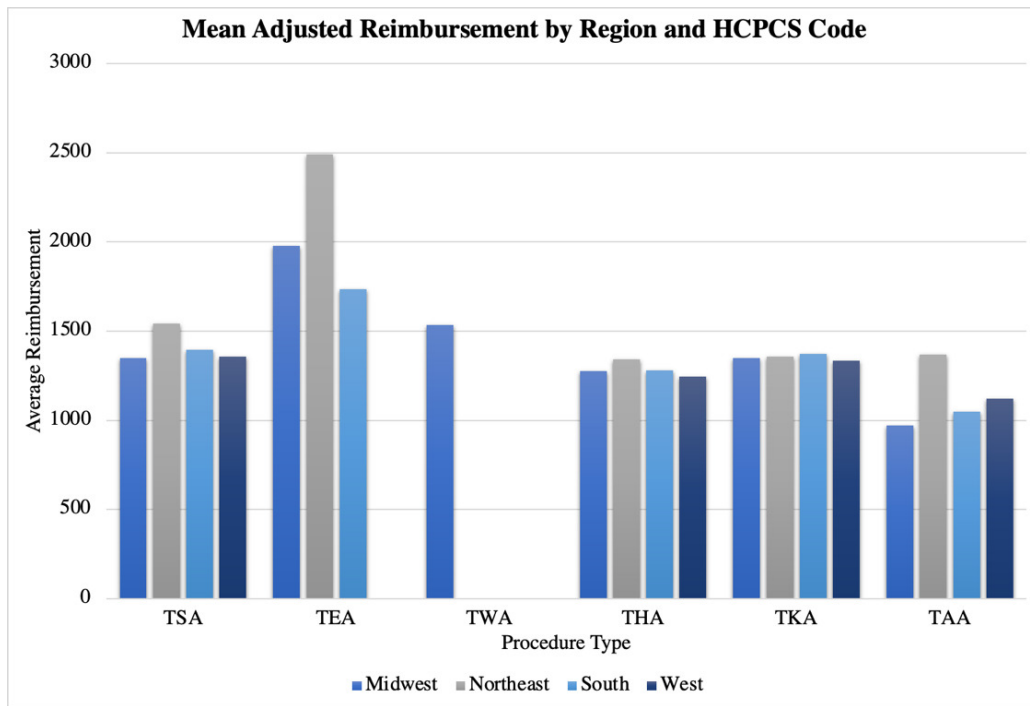


Figure 2A. Mean Adjustment Reimbursement by Region and HCPCS Code.

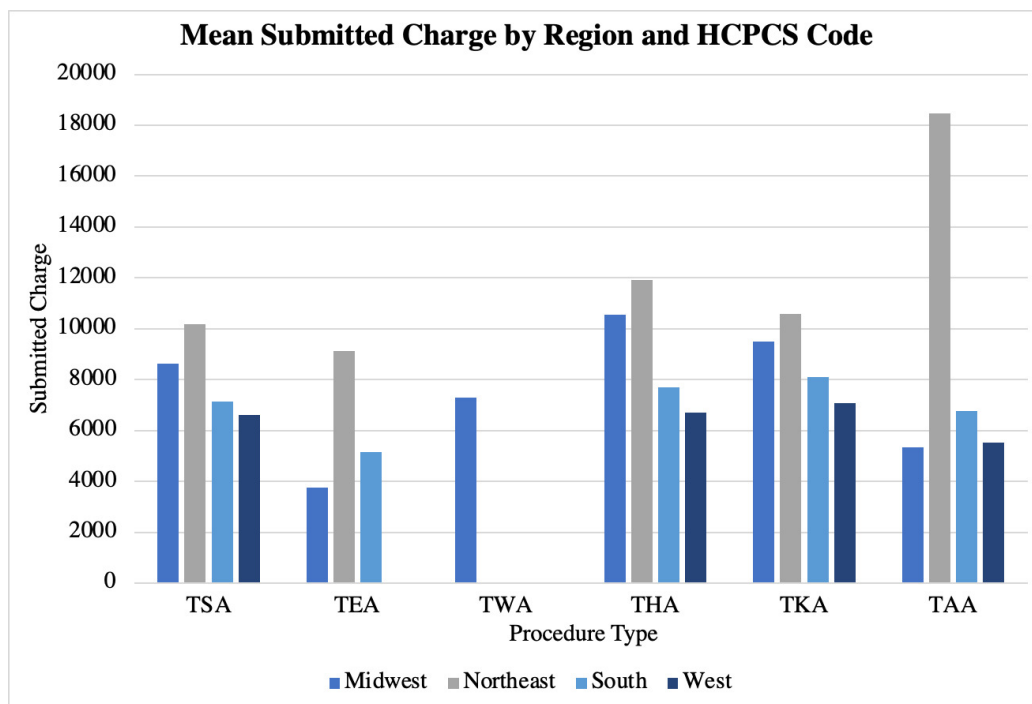


Figure 2B. Mean Beneficiaries by Region and HCPCS Code (*Note to visualize beneficiaries' data a logarithmic scale was used).

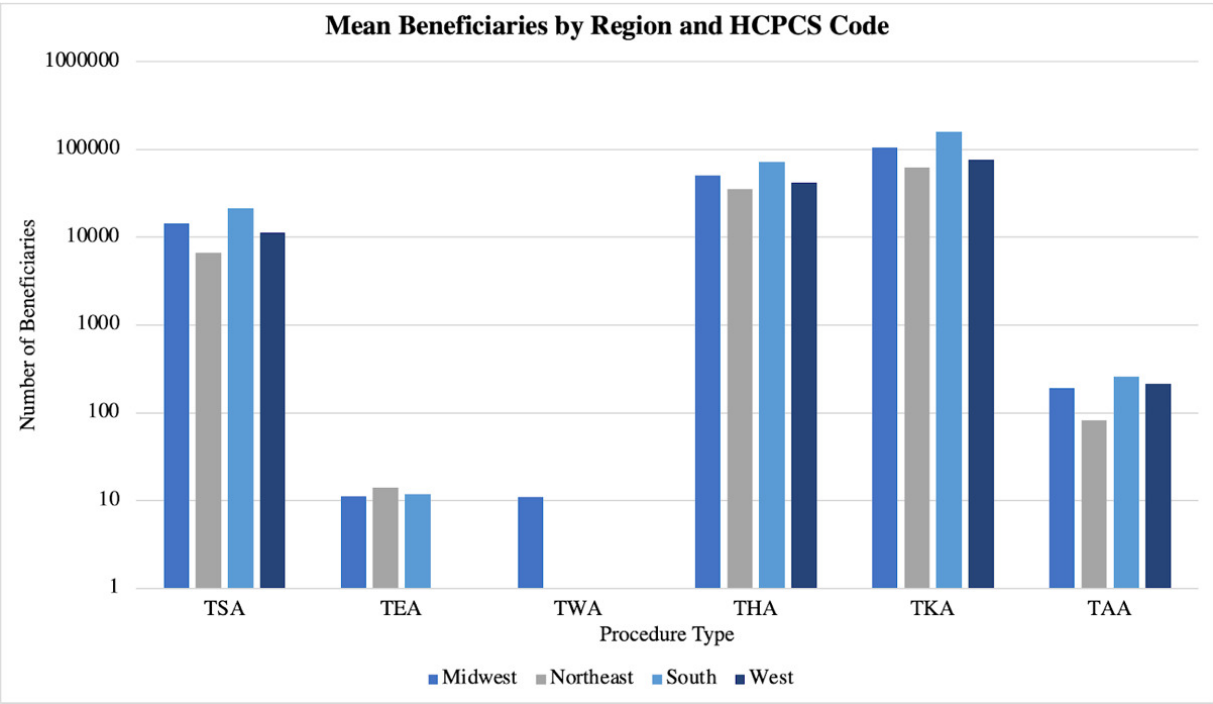


Figure 2C. Mean Submitted Charge by Region and HCPCS Code.

Supplementary Table 1. Rates by year and procedure

HCPSC Code	Year	Total Beneficiaries	Total Services	Mean Adjusted Medicare Payment
23472	2013	31,426	32,208	1,603.03
	2014	36,033	36,806	1,695.92
	2015	42,325	43,155	1,588.11
	2016	48,706	49,754	1,287.92
	2017	55,499	56,499	1,586.75
	2018	63,556	64,697	1,346.56
	2019	73,082	74,473	1,295.08
	2020	61,332	62,459	1,707.47
	2021	70,525	71,794	783.82
24363	2013	14	14	2,489.32
	2016	12	12	1,664.51
	2017	12	12	2,146.04
	2018	11	11	1,906.67
	2019	23	23	1,842.68
25446	2019	11	11	1,536.02
27130	2013	161,660	166,713	1,496.03
	2014	170,217	174,971	1,515.22
	2015	184,413	189,895	1,412.57
	2016	199,199	204,954	1,142.77
	2017	207,739	213,969	1,400.97
	2018	220,539	227,016	1,196.00
	2019	233,783	240,524	1,153.71
	2020	199,804	205,501	1,504.54
	2021	233,059	239,221	839.17
27447	2013	373,050	390,510	1,643.03
	2014	368,874	384,347	1,540.90
	2015	385,593	401,676	1,447.77
	2016	420,641	439,100	1,166.05
	2017	430,033	450,938	1,422.90
	2018	439,644	458,721	1,215.79
	2019	453,812	473,559	1,158.81
	2020	362,636	378,200	1,801.37
	2021	411,546	428,911	881.40
27702	2013	572	579	1,183.47
	2014	647	651	1,365.31
	2015	505	519	1,303.44
	2016	794	809	974.46
	2017	709	717	1,246.33
	2018	950	960	1,035.70
	2019	994	996	966.87
	2020	815	826	1,278.38
	2021	767	771	609.90



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REFERENCES

- Administrator for Community Living. 2021. "2020 Profile of Older Americans." May 2021. https://acl.gov/sites/default/files/Aging%20and%20Disability%20in%20America/2020ProfileOlderAmericans.Final_.pdf.
- "Census Regions and Divisions of the United States." n.d. Accessed March 10, 2024. https://www2.census.gov/geo/pdfs/maps-data/maps/reference/us_regdiv.pdf.
- Centers for Medicare & Medicaid Services Data. n.d. "Medicare Physician & Other Practitioners Methodology." Accessed March 10, 2024. <https://data.cms.gov/resources/medicare-physician-other-practitioners-methodology>.
- Centers for Medicare and Medicaid Services. 2015. "Medicare Program; Comprehensive Care for Joint Replacement Payment Model for Acute Care Hospitals Furnishing Lower Extremity Joint Replacement Services. Final Rule." *Fed Regist* 80 (226): 73273–554.
- CMS.gov. 2021. "Bundled Payments for Care Improvement (BPCI) Initiative: General Information." Baltimore (MD): Centers for Medicare and Medicaid Services. April 12, 2021.
- Committee on Geographic Adjustment Factors in Medicare Payment, Board on Health Care Services, Institute of Medicine, Edmunds M., and Sloan F.A. 2011. "Geographic Adjustment in Medicare Payment: Phase I: Improving Accuracy, Second Edition." Edited by Edmunds M. and Sloan F.A. 5, Geographic Practice Cost Indexes. Washington (DC): National Academies Press (US). <https://www.ncbi.nlm.nih.gov/books/NBK190061/>.
- El-Nahal, W. 2020. "An Overview of Medicare for Clinicians." *Journal of General Internal Medicine* 35 (12): 3702–6. <https://doi.org/10.1007/s11606-019-05327-6>.
- Feng, J. E., A. A. Anoushiravani, L. H. Schoof, J. A. Gabor, J. Padilla, J. Slover, and R. Schwarzkopf. 2020. "Barriers to Revision Total Hip Service Lines: A Surgeon's Perspective Through a Deterministic Financial Model." *Clinical Orthopaedics and Related Research* 478 (7): 1657–66. <https://doi.org/10.1097/CORR.0000000000001273>.
- Fisher, E. S., D. E. Wennberg, T. A. Stukel, D. J. Gottlieb, F. L. Lucas, and E. L. Pinder. 2003. "The Implications of Regional Variations in Medicare Spending. Part 1: The Content, Quality, and Accessibility of Care." *Annals of Internal Medicine* 138 (4): 273–87. <https://doi.org/10.7326/0003-4819-138-4-200302180-00006>.
- Hegde, V., J. B. Stambough, B. R. Levine, and B. D. Springer. 2023. "Highlights of the 2022 American Joint Replacement Registry Annual Report." *Arthroplasty Today* 21:101137. <https://doi.org/10.1016/j.artd.2023.101137>.
- Ibrahim, S. A., H. Kim, and K. J. McConnell. 2016. "The CMS Comprehensive Care Model and Racial Disparity in Joint Replacement." *JAMA* 316 (12): 1258–59. <https://doi.org/10.1001/jama.2016.12330>.
- Jones, C. A., L. A. Beaupre, D. W. Johnston, and M. E. Suarez-Almazor. 2005. "Total Joint Arthroplasties: Current Concepts of Patient Outcomes after Surgery." *Clinics in Geriatric Medicine* 21 (3): 527–vi. <https://doi.org/10.1016/j.cger.2005.02.005>.
- National Academies of Sciences, Engineering, and Medicine, Health and Medicine Division, Board on Health Care Services, and Committee on Health Care Utilization and Adults with Disabilities. 2018. "Health-Care Utilization as a Proxy in Disability Determination." 2, Factors That Affect Health-Care Utilization. Washington (DC): National Academies Press (US). <https://www.ncbi.nlm.nih.gov/books/NBK500097/>.
- Navathe, A. S., J. M. Liao, D. Polsky, Y. Shah, Q. Huang, J. Zhu, Z. M. Lyon, et al. 2018. "Comparison Of Hospitals Participating In Medicare's Voluntary And Mandatory Orthopedic Bundle Programs." *Health Affairs (Project Hope)* 37 (6): 854–63. <https://doi.org/10.1377/hlthaff.2017.1358>.
- Pollock, J. R., T. R. Bollig, J. M. Haglin, B. J. Sandefur, D. E. Rappaport, and R. A. Lindor. 2020. "Medicare Reimbursement to Physicians Decreased for Common Emergency Medicine Services From 2000 to 2020." *Annals of Emergency Medicine* 76 (5): 615–20. <https://doi.org/10.1016/j.annemergmed.2020.06.017>.
- "RBRVS Overview." 2024. American Medical Association. February 21, 2024. <https://www.ama-assn.org/about/rvs-update-committee-ruc/rbrvs-overview>.
- Ritter, M. A., M. J. Albohm, E. M. Keating, P. M. Faris, and J. B. Meding. 1995. "Comparative Outcomes of Total Joint Arthroplasty." *The Journal of Arthroplasty* 10 (6): 737–41. [https://doi.org/10.1016/s0883-5403\(05\)80068-3](https://doi.org/10.1016/s0883-5403(05)80068-3).
- Rothstein, R. 2024. "Examining the Cost of Living by State in 2024." *Forbes*. January 17, 2024. <https://www.forbes.com/advisor/mortgages/cost-of-living-by-state/>.
- Schartz, D., and E. Young. 2021. "Medicare Reimbursement Trends for Interventional Radiology Procedures: 2012 to 2020." *Journal of Vascular and Interventional Radiology: JVIR* 32 (3): 447–52. <https://doi.org/10.1016/j.jvir.2020.12.007>.
- Seidenwurm, D. J., and J. H. Burleson. 2014. "The Medicare Conversion Factor." *AJNR. American Journal of Neuroradiology* 35 (2): 242–43. <https://doi.org/10.3174/ajnr.A3674>.
- Shichman, I., M. Roof, N. Askew, L. Nherera, J. C. Rozell, T. M. Seyler, and R. Schwarzkopf. 2023. "Projections and Epidemiology of Primary Hip and Knee Arthroplasty in Medicare Patients to 2040-2060." *JB & JS Open Access* 8 (1): e22.00112. <https://doi.org/10.2106/JBJS.OA.22.00112>.

- Shiels, M. S., J. S. Almeida, M. García-Closas, P. S. Albert, N. D. Freedman, and A. Berrington de González. 2021. "Impact of Population Growth and Aging on Estimates of Excess U.S. Deaths During the COVID-19 Pandemic, March to August 2020." *Annals of Internal Medicine* 174 (4): 437–43. <https://doi.org/10.7326/M20-7385>.
- Singh, J. A., S. Yu, L. Chen, and J. D. Cleveland. 2019. "Rates of Total Joint Replacement in the United States: Future Projections to 2020-2040 Using the National Inpatient Sample." *The Journal of Rheumatology* 46 (9): 1134–40. <https://doi.org/10.3899/jrheum.170990>.
- Tarakji, B. A., A. T. Wynkoop, A. K. Srivastava, E. G. O'Connor, and T. S. Atkinson. 2018. "Improvement in Depression and Physical Health Following Total Joint Arthroplasty." *The Journal of Arthroplasty* 33 (8): 2423–27. <https://doi.org/10.1016/j.arth.2018.03.051>.
- Testa, E. J., N. J. Lemme, L. T. Li, and S. DeFroda. 2022. "Trends in Operative Duration of Total Shoulder Arthroplasty from 2008 to 2018: A National Database Study." *Shoulder & Elbow* 14 (5): 534–43. <https://doi.org/10.1177/17585732211008900>.
- U.S. Bureau of Labor Statistics. n.d. "Bureau of Labor Statistics Data." U.S. Bureau of Labor Statistics. Accessed March 10, 2024. https://data.bls.gov/timeseries/CUUR0000SA0L1E?output_view=pct_12mths.
- Wagner, E. R., K. X. Farley, I. Higgins, J. M. Wilson, C. A. Daly, and M. B. Gottschalk. 2020. "The Incidence of Shoulder Arthroplasty: Rise and Future Projections Compared with Hip and Knee Arthroplasty." *Journal of Shoulder and Elbow Surgery* 29 (12): 2601–9. <https://doi.org/10.1016/j.jse.2020.03.049>.
- Zmistowski, B., E. M. Padegimas, M. Howley, J. Abboud, G. Williams Jr., and S. Namdari. 2018. "Trends and Variability in the Use of Total Shoulder Arthroplasty for Medicare Patients." *The Journal of the American Academy of Orthopaedic Surgeons* 26 (4): 133–41. <https://doi.org/10.5435/JAAOS-D-16-00720>.