



Pump up the Volume

High-Volume Orthopedic Surgeons Generate Better Outcomes at Lower Costs

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Surgical volume, the frequency with which surgeons and surgery centers perform complex surgical procedures, is clearly understood as a [key determinant](#) of [healthcare quality](#). The Agency for Healthcare Research and Quality (AHRQ) includes “how many times have you done this procedure” as one of the [10 questions](#) patients should ask their doctor. Consumer Reports similarly recommends [patients inquire](#) about surgical volume when choosing a physician. While [over 15 million Americans](#) undergo elective surgery each year, at an estimated total cost of [\\$147.2 billion](#), patients and their families are often unable to consider surgical volume when choosing a provider.

Providers with [higher surgical volume](#) are expected to have fewer medical errors and defects, better acute outcomes overall, and other post-acute benefits following the surgical procedure. However, existing studies have only been able to leverage [relatively small samples of data](#) for specific surgical procedures. There is little to no publicly available information about surgical volume readily accessible for patients, their families, and payers.

In this brief, we use a large, observational sample of national health insurance claims for patients undergoing hip and knee replacement surgeries performed in 2021. Hip and knee surgeries are [the most common](#) elective orthopedic surgical procedures where provider choice is possible for patients, meaning that volume information, if available, could be helpful. We find low provider surgical volume negatively

impacts post-acute outcomes across inpatient and outpatient settings, even after we control for patient characteristics and other factors. We find that treatment by higher-volume surgeons is particularly important for more clinically complex patients.

Major Findings

We analyze two of the most common types of surgical episodes, total hip arthroplasty (THA), commonly known as hip replacements, and total knee arthroplasty (TKA), commonly known as knee replacements. For both hip and knee replacements, higher provider surgical volume is associated with better outcomes across multiple dimensions and multiple care settings, even after adjusting for differences in patient characteristics:

- Lower rates of post-acute inpatient readmission at both 7 and 60 days
- Lower rates of revision surgeries
- Lower rates of post-surgical stay orthopedic specialist visits, emergency department visits, and inpatient days
- Lower episode-level and orthopedic-specific standard dollar amounts

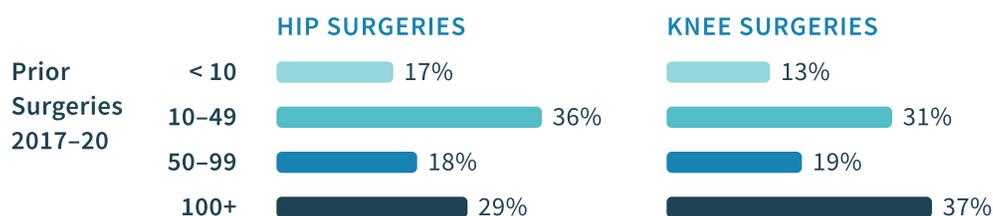
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Variation in Surgical Volume

Using commercial claims data, we calculated historical surgical volume using finalized claims from 2017 to 2020 and assessed recent professional surgical episodes using finalized 2021 claims for hip and knee replacements (identified using HCPCS/ICD-10 PCS). Our analytic sample consisted of 66,367 hip replacements performed by 10,100 providers and 111,666 knee replacements performed by 13,432 providers completed in 2021. We estimate that this sample accounts for approximately 14% of all hip and knee replacements [completed annually in the US](#).

Figure 1 illustrates wide variation in prior surgical volume (2017-2020) for hip and knee replacements performed in 2021. While roughly one-third of 2021 hip and knee replacement episodes were performed by providers with 100 or more prior surgeries, approximately 50% of hip and knee replacement episodes were performed by providers who had performed less than 50 surgeries from 2017-2020; 17% of hip replacements and 13% of knee replacements in 2021 were performed by surgeons with less than 10 prior surgeries documented in the commercial claims data.

Figure 1: Distribution of Surgical Episodes (2021) by Surgical Volume (2017–2020)



The Impact of Surgical Volume on Outcomes and Cost

Figure 2 presents a wide range of post-surgical hip and knee replacement outcomes in 2021 stratified by each surgeon’s volume in the preceding four years. For both the hip and knee replacement samples, higher surgical volume for a provider is associated with better outcomes, specifically:

- Lower rates of post-acute inpatient readmission at 7 and 60 days, with rates for high-volume surgeons between 37-51% less than low-volume surgeons
- Lower rates of revision surgeries
- Lower rates of post-surgical stay orthopedic specialist visits, emergency department visits, and inpatient days
- Lower episode-level and orthopedic-specific Clarify standard amounts,* with total hip and knee episode costs approximately \$2,800 and \$1,500 lower, respectively, when performed by a high-volume versus a low-volume surgeon

Figure 2: Observed Volume-Outcome Relationships for Hip and Knee Replacements

	HIP SURGERIES			KNEE SURGERIES		
	<10 Prior Surgeries	100+ Prior Surgeries	High-Low % Difference	<10 Prior Surgeries	100+ Prior Surgeries	High-Low % Difference
Unique Surgery Episodes (Stay + 90 Days)	11,166	19,426	–	14,060	41,662	–
Episode Clarify Standard Amount*	\$19,988	\$17,150	-14%	\$19,749	\$18,188	-8%
Orthopedic Episode Clarify Standard Amount*	\$17,255	\$15,790	-8%	\$17,594	\$16,758	-5%
Post-Surgery Inpatient Days	0.74	0.25	-66%	0.50	0.23	-54%
Post-Surgery ED Visits	0.13	0.08	-38%	0.13	0.10	-23%
Post-Surgery Orthopedist Office Visits	0.16	0.11	-31%	0.16	0.12	-25%
Acute Admission Rate within 60 Days of Discharge	8.1%	4.0%	-51%	6.9%	4.2%	-39%
Acute Admission Rate within 7 Days of Discharge	3.2%	1.7%	-47%	3.0%	1.9%	-37%
Revision Surgery Rate	4.1%	2.5%	-39%	4.1%	2.4%	-41%

*We derive **Clarify Standard Amounts** by applying Clarify’s standardization methods, aggregating and standardizing across all healthcare services provided during the surgical episode to produce a single monetary measure of resource use.

Surgical Outcomes by Place of Service

When we stratify hip and knee replacements by place of service (inpatient (IP), outpatient (OP), and ambulatory surgical center (ASC) settings), volume-outcome relationships largely remain. As shown in **Figure 3**, for hip replacements, we observe that:

- **Post-surgical ED utilization rates** are approximately 21% lower for high-volume surgeons in an IP setting compared to low-volume surgeons, 35% lower in an OP setting, and 34% lower in an ASC setting
- **Readmission rates** are approximately 32% lower for high-volume surgeons in an IP setting compared to low-volume surgeons, 47% lower in an OP setting, and 74% lower in an ASC setting
- **Revision surgery rates** are approximately 7% lower for high-volume surgeons in an IP setting compared to low-volume surgeons, 40% lower in an OP setting, and 5% higher in an ASC setting

Figure 3: Hip and Knee Surgery Outcome Rates by Surgical Volume and Place of Service



Similarly, for knee replacements, we find that:

- **Post-surgical emergency room utilization rates** are approximately 13% lower for high-volume surgeons in an IP setting compared to low-volume surgeons, 20% lower in an OP setting, and 21% lower in an ASC setting
- **Readmission rates** are approximately 40% lower for high-volume surgeons in an IP setting compared to low-volume surgeons, 32% lower in an OP setting, and 34% lower in an ASC setting
- **Revision surgery rates** are approximately 13% lower for high-volume surgeons in an IP setting compared to low-volume surgeons, 42% lower in an OP setting, and 73% lower in an ASC setting

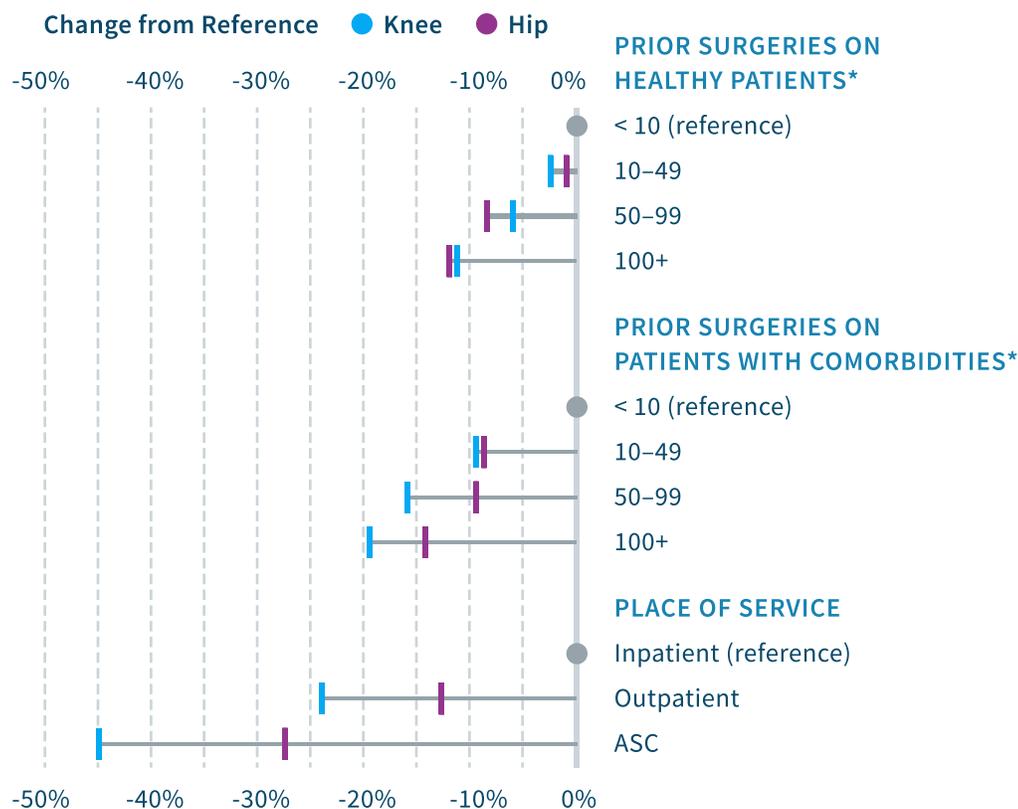
Controlling for Patient Case Mix and Provider Characteristics

While the results presented above are compelling, they could be influenced by patient characteristics or other factors. To control for this, we performed adjusted, multivariate analyses for hip and knee episodes, respectively, and surgical volume controlling for place of service, provider teaching affiliation status, provider state, patient demographics, and comorbidity status. Specifically, we model the probability of a patient experiencing any of three negative clinical events (a post-discharge ED visit, inpatient readmission, or revision surgery) following a joint replacement procedure. Estimates are presented in terms of percentage changes in average rates relative to the low-volume reference group. Our findings of the relationship between surgical volumes and outcomes persist, even after controlling for these other factors.

Figure 4 demonstrates that the impact of surgical volume on outcomes is maintained, albeit at lower levels, even after controlling for patient and provider characteristics for both hip and knee replacements. Further, when we estimate this relationship separately for patients with comorbidities (defined as patients with chronic kidney disease, hypertension, metastatic cancer, obesity, or peripheral vascular disease), we find an even stronger relationship between surgical volume and outcomes. We find that while surgical volume has benefits for all patients, the benefit of experienced surgeons increases for operations on higher acuity patients.

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Figure 4: Adjusted Analysis of Drivers of Post-Surgical Outcomes for Hip and Knee Replacements



*Healthy patients are defined as patients without the reported presence of five selected comorbidities. These comorbidities include chronic kidney disease, metastatic cancer, peripheral vascular disease, hypertension, and obesity.

These estimates imply that all else equal, patients undergoing joint replacement surgery with a high-volume versus low-volume surgeon experience a substantial decrease in risk of experiencing any of the three negative outcomes considered. In terms of percentage changes from the high-volume category to the low-volume reference group, combined rates of post-surgical ED visits, inpatient readmissions, and revisions surgeries are approximately 14% lower for hip replacements and 19% lower for knee replacements, holding patient case mix and provider characteristics fixed. Equally important are place of service considerations. We similarly observe from this analysis that, all else equal, combined rates of negative outcomes for patients treated in outpatient and ASC settings are 13-24% and 27-45% lower on average, respectively, compared to hip and knee replacements performed in IP settings.

Conclusion

Our findings imply clinical benefits for patients who undergo hip and knee replacement surgeries with high-volume surgeons, even after adjusting for patient and other characteristics. Thousands of negative clinical events (i.e., readmissions, emergency department visits, and revision surgeries) could be avoided each year by steering patients to high-volume providers. Our findings here, while not completely ruling out the selection of higher-risk patients into inpatient settings, are also consistent with multiple smaller studies documenting that joint replacement

surgeries completed in OP and ASC settings are associated with [better](#) or [comparable](#) outcomes with IP surgeries, with higher [patient satisfaction](#) and at substantially a [lower cost](#).

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Payers and health systems have begun to concentrate volume of surgeries and other procedures at specific sites within their networks, often referring to these locations as “[centers of excellence](#)” (COEs). For orthopedic surgeries, COEs are [often implemented in OP or ASC settings](#). COEs have higher relative volume, are actively educating care teams about best practices and current medical research, often obtain special accreditations from national organizations and consistently generate improved outcomes versus lower-volume sites of care. Despite this, our study shows many patients continue to see surgeons with lower surgical volumes. In our commercial claims sample, over half of all hip replacements and over 4 in 10 knee replacements were completed by providers with less than 50 observed prior surgeries.

In addition, the general public, to the extent that it is even aware of the impact of surgical volume on outcomes, has few resources to proactively identify high-volume surgeons. One national advocacy organization, [Leapfrog Ratings](#), has requested hospitals and other surgery centers volunteer volumes by surgical category for public reporting, but [response rates to their surveys have been poor](#), with only around 25% of all provider groups reporting, and the general public is mostly unaware of these types of public reporting. CMS also releases [machine-readable data files](#) highlighting annual volume rates for the Medicare population, but this data remains inaccessible to most patients and patient advocates due to its complexity.

Healthcare stakeholders can build on these nascent efforts by:

- **Setting minimum surgical volume standards** for in-network surgeons as well as identifying or creating surgical COEs to better match patients with the right surgeon.
- **Educating surgeons on the importance of gaining sufficient experience** and specialization during their medical training, keeping their surgical volume above minimum thresholds, and continuing medical education around the ethics of scope of practice.
- **Educating consumers and patient advocacy organizations** by releasing comprehensive, multi-payer information on surgical volumes that can be used to identify high-volume, high-quality surgeons for elective surgeries.

Appendix

Limitations

We note several limitations in the presented analyses, primarily arising from the use of commercial insurance claims data. Despite the use of regression analysis to adjust for observable patient characteristics, our review of surgical volume is inherently descriptive. We cannot rule out the impact of selection bias in determining patient-surgeon matching or whether surgeons choose to complete a given surgery within a specific place of service (IP, OP, or ASC). In addition, we only observe surgical episodes within our commercial claims sample, so our estimates of volume are imperfect proxies for overall surgical volume calculated across all payer types. If a surgeon's volume does not vary across insurance types, this will not impact our results. However, as an example, the volume of physicians specializing in replacement surgeries for older patients more likely to have Medicare coverage may be estimated with error. Additional focused evaluations of all-payer data are necessary to fully understand the role of surgical volume on outcomes.

Technical Notes

Identifying surgical procedures

We use both HCPCS and ICD-10 procedure codes to identify joint replacement surgeries. For hip replacements, we consider the CPT codes 27130 and 27132, as well as ICD-10 codes 0SR9019, 0SR901A, 0SR901Z, 0SR9029, 0SR902A, 0SR902Z, 0SR9039, 0SR903A, 0SR903Z, 0SR9049, 0SR904A, 0SR904Z, 0SR9069, 0SR906A, 0SR906Z, 0SR90J9, 0SR90JA, 0SR90JZ, 0SRB019, 0SRB01A, 0SRB01Z, 0SRB029, 0SRB02A, 0SRB02Z, 0SRB039, 0SRB03A, 0SRB03Z, 0SRB049, 0SRB04A, 0SRB04Z, 0SRB069, 0SRB06A, 0SRB06Z, 0SRB0J9, 0SRB0JA, and 0SRB0JZ. For knee replacements, we consider the CPT codes 27440, 27441, 27442, 27443, 27444, 27445, 27446, and 27447, as well as ICD-10 codes 0SRC069, 0SRC06A, 0SRC06Z, 0SRC0J9, 0SRC0JA, 0SRC0JZ, 0SRD069, 0SRD06A, 0SRD06Z, 0SRD0J9, 0SRD0JA, and 0SRD0JZ. Separately, revision surgeries are defined using the set of HCPCS codes available for these follow-up procedures: codes 27134, 27137, 27138 for hip replacements and codes 27486 and 27487 for knee replacements.

Defining surgical volume

We calculate historical surgical volume using finalized prior claims (2017–2020) for the rendering provider, taking count of the number of previously billed surgeries in our sample corresponding to the specific type of surgery (hip replacements or knee replacements, respectively).

Defining standard amounts

Clarify calculates standardized dollar amounts for services comparable to methods applied to Medicare claims by the Centers for Medicaid and Medicare Services (CMS, 2020). Clarify Standard Amount estimates allow for the evaluation of resource use and costs for all services covered across individual commercial payers and regardless of the type of provider. Orthopedic-specific standard amounts are calculated only for services provided by orthopedic specialists.

Defining hip and knee replacement episodes

Hip and knee replacement episodes are defined using event-triggered, 90-day episodes to evaluate provider performance. The episode includes the length of an inpatient admission or the day of the outpatient or ASC surgery, in addition to the following 90 days. These episodes consider all of a patient's claims data to assess all medical events and healthcare utilization during the post-surgical period.

Adjusted analysis

Figure 4 presents percentage change differences in mean outcome rates versus the reference category, utilizing estimates generated from two [linear probability models](#) (ordinary least squares). These models consider a dependent variable indicating if claims associated with the professional episode for the replacement surgery documented any of three negative clinical events: a post-discharge ED visit within 90 days, inpatient readmission within 60 days, or a revision surgery within 90 days. Results for surgical volume are estimated separately (through the use of interaction terms) for 'healthy' patients and patients with one of five prevalent, clinically relevant comorbidities: chronic kidney disease, peripheral vascular disease, metastatic cancer, hypertension, or obesity. Presented estimates are statistically significant at a 90% confidence interval or greater, applying robust standard error methods. Presented models explain approximately 6% of the total variation (i.e., $R^2=.057$) for hip replacement outcomes and approximately 5% of the total variation (i.e., $R^2=.051$) for knee replacement outcomes. Models also control for patient age, prescribing of opioid combination therapies, any skilled nursing facility utilization in the 90 days prior to the episode, and the additional comorbidity indicators: non-metastatic cancer, drug use disorders, alcohol use disorders, coagulopathies, congestive heart failure, complicated diabetes, rheumatoid arthritis and osteoarthritis, hyperlipidemia, tobacco use, and mobility impairments.

About the Clarify Health Institute

The Clarify Health Institute is the research arm of Clarify Health, an enterprise analytics and value-based payments platform company. It leverages Clarify's data assets, including claims, clinical, and social determinants of health data across 300 million patient journeys to shine a light on important healthcare issues and explore trends. It provides industry leaders, policymakers, academic researchers, the media, and the public unprecedented access to data-driven healthcare insights. To learn more, visit clarifyhealth.com/institute.