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The incidence of shoulder arthroplasty: rise and future projections compared with hip and knee arthroplasty

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Background: There remains a paucity of epidemiologic data from recent years on the incidence of shoulder arthroplasty. We aimed to examine the recent trends and predict future projections of hemiarthroplasty (HA), anatomic (aTSA), and reverse shoulder arthroplasty (RSA), as well as compare these predictions to those for total hip (THA) and knee arthroplasty (TKA).
Methods: The National Inpatient Sample was queried from 2011 to 2017 for HA, aTSA, and RSA, as well as TKA and THA. Linear and Poisson regression was performed to project annual procedural incidence and volume to the year 2025.
Results: Between 2011 and 2017, the number of primary shoulder arthroplasties increased by 103.7%. In particular, RSA increased by 191.3%, with 63,845 RSAs performed in 2017. All projection models demonstrated significant increases in shoulder arthroplasty volume and incidence from 2017 to 2025. By 2025, the linear model predicts that shoulder arthroplasty volume will increase by 67.2% to 174,810 procedures whereas the Poisson model predicts a 235.2% increase, to 350,558 procedures by 2025. These growth rate projections outpace those of THA and TKA.
Conclusions: The number of shoulder arthroplasties has been increasing in recent years, largely because of the exponential increases in RSA. The overall incidence is increasing at a greater rate than TKA or THA, with projections continuing to rise over the next decade. These data and projections can be used by policy makers and hospitals to drive initiatives aimed at meeting these projected future demands.
Level of evidence: Descriptive Epidemiology Study using Large Database

Keywords: Incidence; projections; shoulder arthroplasty; reverse; anatomic; hemiarthroplasty; hip and knee arthroplasty

Shoulder arthroplasty is a successful treatment option for a variety of degenerative and traumatic pathologies of the shoulder. It is not surprising, then, that the volume of shoulder arthroplasty has risen over the past few decades.[7,20,22,47] The United States has seen a dramatic increase in the incidence of shoulder arthroplasty over the past decade, correlating with an increasing use of the reverse prosthesis.[7,22,47] Studies examining the incidence of shoulder arthroplasty have analyzed only up to the year 2011 (the first-year reverse shoulder arthroplasty [RSA] was coded separately).[7,20,22,47] Although these studies are informative, they are unable to accurately project future incidence trends given the availability of only 1 data point

Investigation performed at Emory University, Atlanta, Georgia.
As a review of publicly available, deidentified data, this study did not require review by our institutional review board.

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for RSA. Still, given the success of RSA, prior authors have projected an incidence as high as 322% over an 8-year period.[7]

The increase in use of RSA is due to many factors, including its rapidly expanding indications, successful outcomes rivaling anatomic total shoulder arthroplasty (aTSA), and improving implant technology.[21,37] Although there is extensive information on the trends of total hip arthroplasty (THA) and total knee arthroplasty (TKA), there remains a paucity of studies examining recent trends in shoulder arthroplasty. As the population ages in the United States and health care expenditure questions loom, accurate information regarding projected procedural volumes become paramount. Therefore, the purpose of this study was to examine the procedural volume and incidence of shoulder arthroplasty performed in the United States since 2011, analyzing the trends of each specific type of arthroplasty. We also aimed to use these trends to project the future volume and incidence of shoulder arthroplasty. Shoulder arthroplasty trends and projections were then compared with those of THA and TKA over the same time period. We hypothesized that incidence rates have increased for all examined procedures over the study period.

Methods

As a review of publicly available, deidentified data, this study did not require review by our Institutional Review Board. The National Inpatient Sample (NIS), in conjunction with population estimates from the United States Census Bureau, was used to estimate the annual incidence of shoulder, hip, and knee arthroplasty. The NIS uses a sampling method of discharges reported by participating statewide databases to estimate all hospital discharges within the United States. Using International Classification of Diseases 9th revision (ICD-9) and 10th revision (ICD-10) procedure codes, the NIS was queried from 2011 to 2017 for all patients undergoing hemiarthroplasty of the shoulder (HA), aTSA, RSA, TKA, and THA (including hemiarthroplasty). At the time of analysis, 2017 was the most recent data year available from the NIS. National estimates were created with the Complex Samples function of SPSS using discharge weights provided by the NIS. Data were queried beginning in 2011, as the ICD-9 procedure code for reverse shoulder arthroplasty was not distinct and included anatomic total shoulder arthroplasty procedures prior to October 1, 2010. ICD-10 procedure codes were used to query for all arthroplasty procedures occurring after October 1, 2015, when the transition from ICD-9 to ICD-10 took place.

Procedural volume and incidence were estimated for each arthroplasty type. Volume was defined as the total number of procedures in a given time period, whereas the incidence was defined as the volume divided by the total population over a given time period. Incidence is denoted as per 100,000 population. Incidence and volume were also calculated for the subgroups according to age groups ($\leq$55 years, 55-64 years, 65-74 years, and $\geq$75 years) and gender, in addition to the overall incidence and volume in a given year. Percentage change was calculated from 2011 to 2017 and from 2017 to 2025.

Independent Poisson and linear regression models were used to project future volume and incidence for each type of arthroplasty to 2025. An independent linear model was used in conjunction with an exponential (Poisson) projection model, as the exponential model assumes that the current rate of growth will continue ad infinitum, although it is more likely that the true future incidence will lie somewhere between a linear and exponential projection. Separate Poisson and linear models were used for each arthroplasty type to estimate the incidence and volume among age groups and gender, as done previously.[36] Separate models were used for gender and age subgroup projections. All patients undergoing arthroplasty were included in the overall model, but if data were missing for subgroups, these patients were excluded from that specific analysis. Poisson and linear regression analysis was performed using IBM SPSS, version 25.0 (IBM Corp., Armonk, NY, USA).

Results

Overall volume and incidence

Between 2011 and 2017, the number of primary shoulder arthroplasties performed per year increased by 103.7%, from 51,329 to 104,575 (Table I). The annual incidence per 100,000 people in the United States increased by 94.6% from 16.7 in 2011 to 32.6 in 2017 (Table I). In comparison across the same time period, the annual volume of primary THA and TKA increased by 29.1% and 17.8%, respectively, whereas the annual incidence increased by 23.3% and 12.5%, respectively.

RSA, aTSA, and HA volume and incidence

Between 2011 and 2017, the annual volumes of RSA and aTSA increased by 191.3% and 38.5%, respectively (Table II). Alternatively, the volume of HA decreased by 60.9% overall. As demonstrated in Table II, from 2011-2017 the RSA volume increased from 21,916 (incidence of 7.15) to 63,845 (incidence of 19.89). This is in comparison to the aTSAs that increased from 29,414 (incidence of 9.6) to 40,750 (incidence 12.7), and the HAs that decreased from 15,860 (incidence of 5.2) to 6150 (incidence of 1.9).

Table III demonstrates the annual incidence of shoulder arthroplasties stratified by sex and age. There was growth in all subgroups for aTSA and rTSA. The largest overall growth for rTSA was seen in men and women aged 55-64 years, with an increase of 192.1% and 193.2%, respectively. Likewise, for aTSA, the largest overall growth was seen in women 55-64 years old, with an increase of 36.3%. The age and sex group with the highest incidence of rTSA was men and women $\geq$75 years old, with an incidence of 99.9 and 130.2, respectively. The age and sex group with the highest incidence of aTSA was men and women 65-74 years old, with an incidence of 66.9 and 61.8, respectively.

Table I Shoulder, hip, and knee arthroplasty volume and incidence, 2011-2017

Year	Shoulder arthroplasty (reverse, total)		Total hip arthroplasty		Total knee arthroplasty	
	Volume	Incidence	Volume	Incidence	Volume	Incidence
2011	51,329 (45,480-57,179)	16.74 (14.83-18.65)	412,091 (385,782-438,399)	134.4 (125.8-143.0)	645,062 (599,728-690,397)	210.4 (195.6-225.2)
2012	55,375 (52,093-58,657)	17.91 (16.85-18.97)	416,890 (400,925-432,855)	134.9 (129.7-140.0)	631,264 (606,886-655,642)	204.2 (196.3-212.1)
2013	64,995 (61,273-68,717)	20.86 (19.67-22.06)	440,775 (423,186-458,364)	141.5 (135.8-147.1)	662,545 (636,807-688,283)	212.7 (204.4-220.9)
2014	74,050 (70,111-77,989)	23.57 (22.32-24.83)	470,610 (452,670-488,551)	149.8 (144.1-155.5)	680,886 (654,576-707,195)	216.8 (208.4-225.1)
2015	83,150 (78,948-87,352)	26.27 (24.94-27.60)	493,480 (475,061-511,898)	155.9 (150.1-161.7)	704,979 (678,548-731,410)	222.7 (214.4-231.1)
2016	93,115 (88,451-97,779)	29.23 (27.77-30.69)	518,045 (498,035-538,056)	162.6 (156.3-168.9)	743,516 (715,636-771,395)	233.4 (224.6-242.2)
2017	104,575 (99,416-109,734)	32.58 (30.97-34.18)	532,110 (511,403-552,816)	165.8 (159.3-172.2)	759,924 (730,734-789,115)	236.7 (227.6-245.8)
Percent change	103.7	94.6	29.1	23.3	17.8	12.5

Values within parentheses are 95% confidence intervals; incidence is represented as per 100,000 population.

Table II Shoulder arthroplasty volume and incidence, 2011-2017

Year	Reverse shoulder arthroplasty		Anatomic shoulder arthroplasty		Shoulder hemiarthroplasty	
	Volume	Incidence	Volume	Incidence	Volume	Incidence
2011	21,916 (18,823-25,009)	7.15 (6.14-8.16)	29,414 (26,188-32,640)	9.59 (8.54-10.65)	15,860 (14,510-17,210)	5.17 (4.73-5.61)
2012	24,465 (22,717-26,213)	7.91 (7.35-8.48)	30,920 (29,030-32,810)	10.00 (9.39-10.61)	12,920 (12,245-13,595)	4.18 (3.96-4.40)
2013	30,850 (28,790-32,910)	9.90 (9.24-10.56)	34,155 (32,046-36,264)	10.96 (10.29-11.64)	11,180 (10,556-11,804)	3.59 (3.39-3.79)
2014	38,180 (35,867-40,493)	12.16 (11.42-12.89)	35,885 (33,801-37,969)	11.42 (10.76-12.09)	9210 (8619-9801)	2.93 (2.74-3.12)
2015	47,220 (44,553-49,887)	14.92 (14.08-15.76)	35,950 (33,894-38,006)	11.36 (10.71-12.01)	8335 (7807-8863)	2.63 (2.47-2.80)
2016	54,940 (51,957-57,923)	17.25 (16.31-18.18)	38,190 (35,969-40,411)	11.99 (11.29-12.69)	7290 (6761-7819)	2.29 (2.12-2.45)
2017	63,845 (60,541-67,149)	19.89 (18.86-20.92)	40,750 (38,374-43,126)	12.69 (11.95-13.43)	6150 (5670-6630)	1.92 (1.77-2.07)
Percent change	191.3	178.3	38.5	32.3	−60.9	−62.7

Values within parentheses are 95% confidence intervals; incidence is represented as per 100,000 population.

Table III Shoulder arthroplasty incidence, 2011-2017

	Reverse shoulder arthroplasty			Anatomic shoulder arthroplasty			Shoulder hemiarthroplasty		
	2011	2017	% change	2011	2017	% change	2011	2017	% change
Male									
≤55 yr	0.32 (0.19-0.45)	0.78 (0.65-0.91)	144.3	1.65 (1.35-1.96)	2.05 (1.82-2.28)	23.9	1.39 (1.13-1.64)	0.75 (0.62-0.87)	−46.2
55-64 yr	8.43 (6.51-10.34)	24.61 (22.51-26.71)	192.1	25.52 (21.99-29.05)	30.98 (28.38-33.57)	21.4	10.05 (8.62-11.48)	4.10 (3.40-4.80)	−59.2
65-74 yr	29.29 (23.90-34.68)	83.45 (77.70-89.20)	185.0	55.67 (48.46-62.87)	66.96 (62.13-71.79)	20.3	14.52 (12.28-16.76)	5.87 (4.84-6.90)	−59.6
≥75 yr	44.18 (37.64-50.72)	99.85 (92.73-106.97)	126.0	37.81 (32.90-42.71)	41.11 (37.15-45.07)	8.7	15.66 (13.23-18.09)	3.84 (2.85-4.84)	−75.5
Female									
≤55 yr	0.39 (0.28-0.50)	0.84 (0.71-0.98)	118.2	0.95 (0.77-1.13)	1.18 (1.02-1.33)	24.3	0.92 (0.74-1.11)	0.45 (0.36-0.55)	−51.2
55-64 yr	9.67 (7.65-11.68)	28.34 (26.22-30.45)	193.2	16.88 (14.60-19.15)	23.01 (21.15-24.86)	36.3	10.88 (9.57-12.19)	3.81 (3.20-4.43)	−64.9
65-74 yr	42.49 (36.45-48.52)	113.07 (106.45-119.69)	166.1	53.78 (47.30-60.25)	61.79 (57.45-66.14)	14.9	25.68 (22.86-28.50)	7.48 (6.45-8.50)	−70.9
≥75 yr	61.84 (53.25-70.43)	130.24 (122.67-137.81)	110.6	40.57 (35.92-45.21)	41.72 (38.27-45.18)	2.9	34.88 (31.13-38.63)	8.15 (6.95-9.34)	−76.7

Values within parentheses are 95% confidence intervals; incidence is represented as per 100,000 population.

Projections

Linear and Poisson regression analyses demonstrated significant increases in cumulative shoulder arthroplasty volume and incidence from 2017-2025 (Figs. 1 and 2, Table IV). By 2025, the linear model predicts that shoulder arthroplasty volume will increase by 67.9% to 174,810 cases/yr (Fig. 1). According to the Poisson model, the projected volume increase will be 235.2% to 350,558 by 2025 (Fig. 2). This is in comparison to the linear and Poisson volume estimates of THA to increase by 33.6% and 47.1%, respectively, and of TKA to increase by 22.4% and 22.1%, respectively (Table IV).

The projections specifically for rTSA also demonstrated substantial increases, with projected volume increases by the linear and Poisson models of 87.9% and 353.0%, to an estimated 119,994 and 289,193 procedures, respectively. Likewise, the linear and Poisson models saw an increase of 34.5% and 50.6% for aTSA, to a projected 54,815 and 61,366 procedures (Figs. 3 and 4, Table V). Alternatively, HA was projected to decrease by 71.6% on the linear model, to 1905 procedures.

The linear and Poisson models stratified by age and sex subgroups are seen in Tables IV and V.

Discussion

The incidence of shoulder arthroplasty has been increasing in recent years,[7,20,22,47] largely because of the expanding indications for RSA.[7,22,47] Since the first description of the "reverse" shoulder prosthesis by Paul Grammont in 1993,[14] the indications for the procedure have expanded beyond massive irreparable rotator cuff tears.[3,14,27,32,45] In addition to irreparable cuff tears, RSA can be used to successfully manage rotator cuff arthropathy,[3,13,27,35] inflammatory arthritis,[16,17] instability,[24] glenoid bone loss,[11,29,38] acute fractures,[1,8,12,34] post-traumatic reconstruction,[34,44] humeral bone loss,[5,23,33] brachial plexus sequelae,[10,46] and failed prior arthroplasties.[6,30,39-43] Approval of RSA for use in the United States in late 2004 signaled an inflection point for the global use of RSA; however, the contemporary effect of this expansion has yet to be quantified, given coding limitations corrected in late 2010.[7,20,22,47] Therefore, we quantified the incidence of all shoulder arthroplasties since 2011, while projecting the future increases and comparing these projections to THA and TKA.

From the years 2011-2017, the shoulder arthroplasty volume and incidence per 100,000 people increased by ~100%, and our Poisson model predicts it to increase by an additional 235.2% by the year 2025. The number of RSAs increased by 191%, growing from ~22,000 performed annually in 2011 to ~64,000 in 2017. The number of RSAs performed in 2025 is projected (Poisson) to increase by ~353% to ~289,000. These numbers are in comparison to an increase in THA of ~29% and TKA of ~18% from 2011 to 2017, and a projected (Poisson

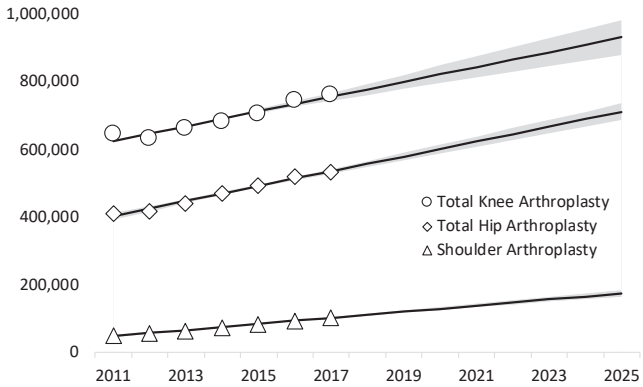

Figure 1 Projected estimates of knee, hip, and shoulder arthroplasty to 2025 using a linear regression model, with 95% confidence intervals in gray.

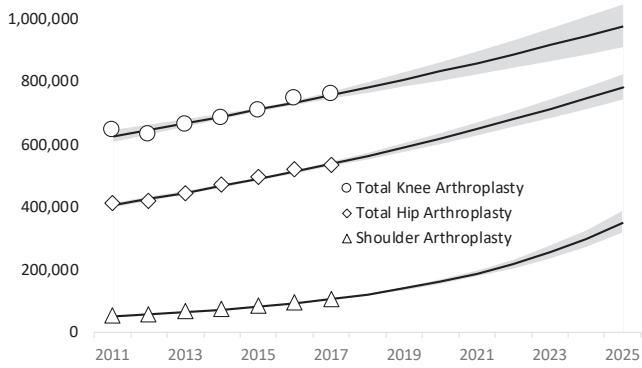

Figure 2 Projected estimates of knee, hip, and shoulder arthroplasty to 2025 using a Poisson regression model, with 95% confidence intervals in gray.

model; by the year 2025) increase of 47% and 22% for THA and TKA, respectively.

The results from the current investigation are consistent with past literature. Although it was initially reported that the incidence of TSA was increasing slowly (1990-2000),[19] this has quickly changed. Multiple authors have since reported dramatic increases in the incidence of TSA.[9,18,22] The incidence has been reported to have increased 250% from 2000-2008,[22] and by 369% from 1993-2007.[7] This increase has outpaced what would be expected from increases in population and surgeon density alone. We found a similar trend in exponential rise in shoulder arthroplasties over more recent years, with an average of ∼15% yearly increase from 2011 to 2017.

An important aspect of our study was the comparison of current trends in shoulder arthroplasty to those in total hip and knee arthroplasty. Early studies (1990s) showed annual growth in incidence for hip and knee arthroplasty that far outpaced the slowly growing TSA incidence over the same period.[19,25,26] However, from 2000-2014, although THA continues to grow linearly at an ∼6% annual growth rate, the observed annual growth rates of TKA has slowed from 10.2% from 2000-2008 to 3.6% from 2008-2014.[36] Although the incidence of shoulder arthroplasty remains a fraction of the annual incidence of lower extremity arthroplasty, it is increasing at a rate that is much greater than that of TKA and THA. Interestingly, the mean annual growth rate of the RSA is nearly 6.5-fold greater than TKA and more than triple that of THA over similar time periods.

Multiple authors noted an acceleration in the incidence of TSA after the 2003 Food and Drug Administration (FDA) approval of the reverse TSA device in the United States.[7,22] Day et al[7] noted a sudden increase in annual incidence toward the end of the study period from 1993-2007 corresponding to the FDA approval of RSA in late 2004. Kim et al[22] also saw an exponential jump in shoulder arthroplasty usage from 2004-2008 compared with a linear increase from 1993-2003. More recently, the incidence of shoulder arthroplasty was noted to steadily increase from 2009-2011 by 128%, with 42% of all primary arthroplasties in 2011 involving RSAs.[20] However, these and other studies are only up to the year 2011 in the United States,[20,47] without insight into recent trends in the United States. However, 2 international registry studies found use rates of RSA to increase at similar rates to those we found in the United States.[15,28] Our study has expanded on the projections of many of these prior studies within the United States, showing the dramatic impact RSA has had on the usage of shoulder arthroplasties in recent years. From 2011-2017, the annual incidence of aTSA increased by ∼32% and HA decreased by ∼62%, compared with an ∼180% increase by RSA.

Additionally, it is possible these findings could even underestimate the projected increases of arthroplasties, as recent years have seen the expansion of outpatient total joint arthroplasty.

These exponential increases in shoulder arthroplasty are probably due to multiple factors, including evolving surgical techniques, understanding of various shoulder pathologies, and improving implant technology. The RSA will likely continue to play a major role in the future projected rise, as it has developed over the last 15 years from a salvage operation to one that rivals aTSA in most areas, including pain relief, shoulder motion and function, implant survival, and complications.[21,37] Furthermore, the indications for all shoulder arthroplasties, particularly RSA, should continue to expand. For example, there has been increasing demand in young patients (<55 years old), which is projected to increase by 333% from 2011-2030.[31] In our study, we also found an increase in patients younger than 55 years, as well as those between 55 and 64 years old. As the incidence of RSA continues to expand, especially in younger age groups who may require revision surgery as they age, it is important to consider the demanding and technically challenging nature of RSA.

There are multiple limitations that should be considered when interpreting the results of this investigation, mostly inherent to the deficiencies of a large administrative database. The accuracy of our findings are reliant on the

Table IV Projected volume estimates of shoulder, knee, and hip arthroplasty in 2025

	Shoulder arthroplasty (anatomic, reverse)		Total hip arthroplasty		Total knee arthroplasty	
	Poisson	Linear	Poisson	Linear	Poisson	Linear
Overall	350,558 (315,717-389,503)	174,810 (164,243-185,376)	782,514 (743,006-824,122)	710,778 (686,526-735,031)	975,456 (908,494-1,047,354)	929,981 (878,190-981,772)
% change*	235.2	67.2	47.1	33.6	22.1	22.4
Sex						
Male	159,817 (141,324-181,024)	75,437 (70,588-80,286)	347,507 (326,150-370,262)	307,840 (296,698-318,982)	389,249 (362,922-417,487)	366,465 (346,629-386,301)
Female	193,740 (175,563-213,850)	99,438 (93,636-105,239)	437,568 (417,694-458,387)	403,587 (390,024-417,150)	588,185 (549,765-629,291)	564,386 (534,121-594,651)
Total	353,558 (316,887-394,874)	174,875 (164,224-185,525)	785,075 (743,844-828,649)	711,427 (686,722-736,132)	977,435 (912,687-1,046,778)	930,851 (880,750-980,952)
Age groups						
<55 yr	12,784 (10,118-16,534)	8435 (7796-9074)	84,343 (73,286-97,069)	82,325 (72,919-91,731)	71,862 (65,353-79,020)	71,085 (63,300-78,871)
55-64 yr	81,847 (69,220-96,788)	37,039 (33,719-40,359)	228,135 (205,611-253,126)	192,930 (183,084-202,777)	281,256 (259,563-304,763)	271,283 (254,674-287,892)
65-74 yr	185,772 (162,794-212,130)	78,104 (72,999-83,209)	312,760 (298,896-327,268)	247,420 (241,747-253,093)	463,834 (440,408-488,506)	409,549 (392,055-427,042)
≥75 yr	88,608 (80,062-98,082)	51,302 (47,726-54,879)	191,447 (171,549-213,652)	188,309 (170,821-205,796)	183,442 (158,950-211,708)	178,383 (157,262-199,503)
Total	369,011 (322,193-423,534)	174,880 (162,240-187,520)	816,685 (749,342-891,115)	710,984 (668,571-753,397)	1,000,395 (924,273-1,083,997)	930,299 (867,290-993,308)

* Percentage change compared with 2017.

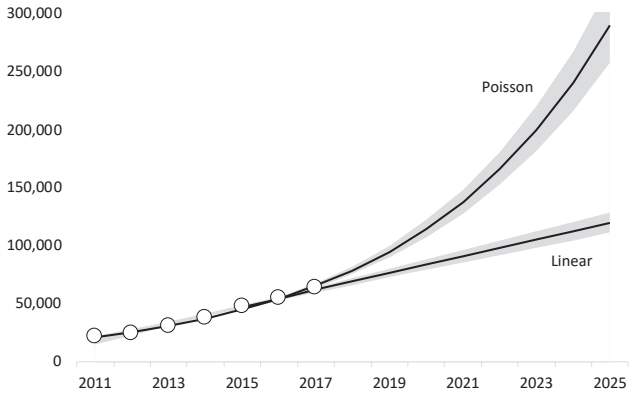

Figure 3 Projected estimates of reverse shoulder arthroplasty to the year 2025 with a linear and Poisson regression model. The gray zone indicates 95% confidence intervals.

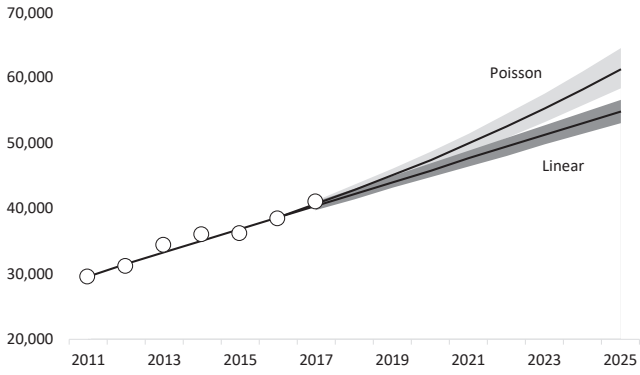

Figure 4 Projected estimates of anatomic total shoulder arthroplasty to the year 2025 with a linear and Poisson regression model. The gray zone indicates 95% confidence intervals.

accuracy of various codes entered into the database. This could allow certain patients or procedures to be overlooked, if the codes are incorrect or omitted or if their treatment is not reimbursable. Furthermore, we are unable to model in smaller subpopulations where a stratified sample of discharge records does not represent the true procedural volume. Therefore, we only stratified by age and gender to avoid this potential error. Nevertheless, the NIS database represents the best available database to analyze national trends irrespective of payer status.[2] Another important set of limitations deals with the inability to validate the accuracy of future projections. Naturally, there are many drivers of procedural growth over time, some of which we cannot predict. However, we used 2 different project models to estimate these groups in an attempt to overcome this limitation. Of note, using data until 2007, Day et al[7] used Poisson regression modeling to project a rise to close to 40,000 total shoulder arthroplasties by the year 2013. This number was actually an underestimate of the procedural volume demonstrated in our study, as there were ~65,000 shoulder arthroplasties performed in 2013.

Table V Projected volume estimates of shoulder arthroplasty types in 2025

	Reverse shoulder arthroplasty		Anatomic shoulder arthroplasty		Hemiarthroplasty*
	Poisson	Linear	Poisson	Linear	Poisson
Overall	289,193 (257,294-325,046)	119,994 (111,190-128,799)	61,366 (58,423-64,456)	54,815 (53,054-56,577)	1749 (1566-1952)
% change†	353.0	87.9	50.6	34.5	−71.6
Sex					
Male	127,771 (110,636-147,560)	47,312 (43,222-51,402)	32,046 (30,689-33,464)	28,126 (27,367-28,885)	968 (842-1113)
Female	164,254 (147,864-182,460)	72,698 (68,005-77,390)	29,486 (27,699-31,389)	26,740 (25,631-27,849)	850 (777-931)
Total	292,025 (258,499-330,021)	120,009 (111,227-128,792)	61,533 (58,388-64,853)	54,865 (52,998-56,733)	1818 (1618-2044)
Age groups					
≤55 yr	7584 (5227-11,006)	3606 (3193-4019)	5200 (4891-5529)	4829 (4603-5055)	586 (519-662)
55-64 yr	62,706 (52,719-74,584)	20,922 (18,735-23,109)	19,141 (16,500-22,204)	16,117 (14,984-17,249)	538 (505-573)
65-74 yr	156,279 (135,401-180,377)	53,154 (49,159-57,150)	29,493 (27,393-31,753)	24,950 (23,840-26,059)	536 (448-643)
≥75 yr	79,542 (72,160-87,680)	42,338 (39,851-44,825)	9066 (7902-10,401)	8964 (7875-10,054)	244 (196-305)
Total	306,112 (265,507-353,647)	120,020 (110,938-129,103)	62,899 (56,686-69,887)	54,860 (51,303-58,417)	1905 (1668-2184)

* Linear model crosses 0, predicts in negative range.
† Percentage change compared with 2017.

Additionally, NIS estimates of shoulder arthroplasty may underestimate the true volume, as there has been a rise in ambulatory procedures with the growth in physician and hospital competency with the procedure. Although shoulder arthroplasty primarily remains an inpatient procedure, there has been a slight rise in the incidence of ambulatory shoulder arthroplasty, which would not be captured with the NIS.[4] However, there are no nationally representative databases that can adequately estimate outpatient shoulder arthroplasty volume for all payers, hence the exclusion of outpatient surgery for this study.

Conclusion

The procedural volume and incidence of shoulder arthroplasty continues to rise at an exponential rate, corresponding with the increasing use of the reverse prosthesis. This rate has outpaced THA and TKA in recent years. From the years 2017-2025, there is a projected ∼235% increase in the annual volume of shoulder arthroplasties performed, compared with a 47% increase for THA and 22% increase for TKA. However, the volume of THA and TKA are projected to still markedly outnumber TSA in 2025. Furthermore, these findings represent important considerations for policy makers and administrators. In addition, this will lay a foundation for future investigations into resource allocation and cost-effectiveness.

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