

The Characteristics of Surgeons Performing Total Shoulder Arthroplasty: Volume Consistency, Training, and Specialization

Publish date: December 19, 2018

Authors:

Benjamin Zmistowski MD William Warrender Michael Livesey BS Alex Girden Gerald R Williams Jr Surena Namdari MSC

Author Affiliation | **Disclosures**

Dr. Zmistowski and Dr. Warrender are orthopedic surgery residents, Thomas Jefferson University, Philadelphia, Pennsylvania. Mr. Livesey and Mr. Girden are medical students, Sidney Kimmel Medical College at Thomas Jefferson University, Philadelphia, Pennsylvania. Dr. Williams is Professors of Shoulder and Elbow Surgery and Dr. Namdari is an Associate Professor of Orthopedic Surgery, Rothman Institute at Thomas Jefferson University, Philadelphia, Pennsylvania.

Authors' Disclosure Statement: The authors report no actual or potential conflict of interest in relation to this article.

Address correspondence to: Surena Namdari, MD MSc, Rothman Orthopaedic Institute, 925 Chestnut Street, 5th Floor, Philadelphia, PA 19107 (tel, 267-339-3738; email, surena.namdari@rothmanortho.com).

Am J Orthop. 2018;47(12). Copyright Frontline Medical Communications Inc. 2018. All rights reserved.

With the adoption of reverse shoulder arthroplasty, utilization of total shoulder arthroplasty (TSA) has increased substantially over the last decade.¹⁻³ Such increases are likely secondary to an aging population, increased comfort with the procedure, and the adoption of broadened indications for reverse shoulder arthroplasty, especially in the setting of proximal humerus fractures in the elderly.⁴⁻⁷ Between 2012 and 2014 alone, the number of surgeons performing >10 TSA in Medicare patients annually increased by 28.6% (824 to 1060 surgeons) providing a 26.6% (20,824-26,365 procedures) increase in national volume in the Medicare population.² With this boom in utilization, scrutiny of this now routine procedure and those performing it is necessary.

Prior reviews have demonstrated a strong link between surgeon and hospital TSA volume and outcomes of the procedure.⁸⁻¹⁰ Somerson and colleagues¹¹ investigated fellowship training among surgeons performing TSA in 2012 and found that only 28% had completed a shoulder and elbow fellowship. In addition to prior analyses^{2, 12}, Somerson and colleagues confirmed a persistent geographic variation in utilization of TSA.¹¹ In conjunction with the evolution of shoulder arthroplasty, dedicated shoulder and elbow fellowship training has expanded. With a shift toward specialization in care, nearly 90% of orthopedic surgery residents plan to pursue shoulder and elbow fellowships, comprising 4.6% of (42/897) of available positions.¹³

What remains unknown is the specialization of surgeons performing TSA, the regularity of their arthroplasty volume, and trends in TSA specialization over time. Therefore, this study aims to (a) identify surgeons performing shoulder arthroplasty and cohort changes over time, (b) determine the case profile of surgeons consistently performing shoulder arthroplasty, and (c) establish the characteristics of shoulder arthroplasty surgeons with a specific focus on fellowship training.

METHODS

Prior to collecting surgeon-specific data, we identified surgeons performing TSA through the Centers for Medicare and Medicaid Services' public release of "Medicare Provider Utilization and Payment Data: Physician and Other Supplier."¹⁴ Datasets from 2012, 2013, and 2014 were used to identify all surgeons performing >10 TSAs (Current Procedural Terminology [CPT] Code 23472) during at least 1 of those years. This dataset provides the name, identification number, address, and all billing (by volume) for each unique CPT code submitted ≥ 10 times in a calendar year.

Once the cohort of surgeons had been generated, the number of surgeons consistently performing TSA year-over-year was determined. This allowed for an analysis of the consistency with which surgeons are performing moderate- to high-volume TSA. To form a case profile of surgeons performing TSA and observe how this shifted over time, a count and a description of each CPT code submitted by each surgeon was identified. To maintain patient privacy, only those claims made >10 times are reported for a provider (both physicians and physician-extenders are included in this dataset). First, all CPT codes were reviewed and tagged as surgical or non-surgical events. Then, every procedural CPT code identified was reviewed and categorized based upon anatomic location and procedure (eg, total knee arthroplasty [TKA]). It is important to note that all claims in this dataset are limited to those patients participating in Medicare's fee-for-service program.

Specialization was defined as the number of categorized procedures as a percentage of all procedures performed on Medicare patients. The trends for national, regional, and individual specialization of TSA, arthroplasty (major joint), and shoulder procedures were determined.

To investigate the characteristics of surgeons consistently performing TSA, all surgeons performing a minimum of 11 TSA in Medicare fee-for-service beneficiaries in all years between 2012 and 2014 were identified. Such surgeons were defined as consistent TSA surgeons. Investigation of this cohort included a web-based search of their self-reported post-graduate fellowship training and year of graduation from medical school. Using these data, the percentage of surgeons performing TSA who underwent formal shoulder and elbow training was determined. In addition, the impact of fellowship training on shoulder specialization and practice location was determined. Surgeons who had completed multiple fellowships were categorized under all of them. As such, there may be some duplication of surgeons in the comparisons. In addition, other potential characteristics of shoulder and elbow fellowship-trained surgeons were investigated: number of regional shoulder surgeons, urban area, total number of Medicare beneficiaries, average reimbursement for TSA, ethnicity of Medicare beneficiaries, and percentage of Medicare patients eligible for Medicaid. Geographic regions were defined by the Dartmouth Atlas and assigned by hospital referral region.¹⁵ These defined regions were used to assess the beneficiaries (number and characteristics) that individual surgeons were likely serving. The United States Census Bureau characterization of zip code-based regions as urban areas (population >50,000), urban clusters (2500 to 50,000), and rural region (<2500) was used to categorize practice location.¹⁶

Descriptive statistics were used initially to report these findings. To analyze predictors of utilization and specialization, comparative statistics were undertaken. For comparison of binomial variables between groups, a

χ^2 analysis was utilized. For continuous variables, data normality was assessed. A skewness and kurtosis <2 and 12 , respectively, was considered to represent parametric data. For parametric data, the mean was reported; conversely, the median is reported for non-parametric data. To assess continuous variables between groups, a t test or a Wilcoxon rank-sum test was used for parametric and non-parametric distributions, respectively.

RESULTS

Between 2012 and 2014, 1374 surgeons (39 females [2.8%]) performed >10 TSA in Medicare patients in at least 1 year, for a combined total of 71,973 TSAs (**Table 1**). In 2012, only 834 surgeons (13 females [1.6%]) performed a minimum of 10 TSA in Medicare patients (21,137 arthroplasties; 25.3 per surgeon). This increased to 1078 surgeons (33 females [3.1%]; $P = .04$) performing 26,865 TSA (24.92 per surgeon) in 2014. Utilization of non-physician assistants in TSA also increased significantly over this period, with 307 assisting in 6885 TSAs (22.4 per provider) in 2012 and 465 assisting 10,433 TSA (22.4 per provider) in 2014. When all procedures were considered, including those performed at outpatient visits, 1319 physicians (95.9% of cohort) were active in 2012—providing either surgical procedures or outpatient consults to the Medicare population. Yet, only 63.2% performed >10 TSA in Medicare patients. The number of active surgeons performing TSA increased to 79.6% (1078/1353) in 2014 ($P < .001$).

In addition to TSA, this cohort of surgeons submitted 240 unique CPT codes with case volumes >10 annually over the 3-year study period. Of these, 80.2% (1102/1374) of surgeons performed non-arthroplasty shoulder procedures on Medicare patients, for a combined total of 202,335 procedures over the 3-year study period (**Table 2**). A significant proportion of these procedures were arthroscopic debridement (60,014 procedures performed by 908 surgeons) and arthroscopic rotator cuff repair (47,089 procedures performed by 809 surgeons). Just under half (49.1%; 674/1374) of surgeons performing TSA also performed TKA during this period (77,873 arthroplasties). Fewer surgeons (27.8%; 382/1374) performed total hip arthroplasty during this period (27,322 arthroplasties). Other procedure types that this group of surgeons routinely performed on Medicare patients were repairs of traumatic injuries (29.8%), non-arthroplasty knee surgeries (27.2%), elbow procedures (19.6%), and hand surgery (15.4%). By case load, non-arthroplasty shoulder procedures consisted of 43% of Medicare volume over the study period (**Figure 1**). Between 2012 and 2014, the average proportion of Medicare cases that were shoulder arthroplasties increased from 13.8% (21,137/152,862) to 16.7% (26,865/160,851; $P = .001$). Shoulder arthroplasty constituted 100% of the Medicare surgical case volume for 67 (4.9%; 67/1374) of the surgeons.

Only 44.3% (609/1374) of surgeons performed TSA in a minimum of 11 Medicare patients in all 3 years of the study period (consistent providers of TSA), providing a total of 55,538 TSA (77.2%; 55,538/71,973). When fellowship training was evaluated, 191 (31.4%; 191/609) of these surgeons were shoulder and elbow fellowship trained (21,444 TSA; 38.6%; **Table 3**). More than one-third (36.6%; 223/609) had completed a sports surgery fellowship (18,899 TSA; 34.0%). Surgeons trained in hand surgery (12.5%; 76/609) and adult reconstruction (5.3%; 32/610) also made contributions to meeting the TSA demand with 6971 (12.6%) and 2485 (4.5%) TSA, respectively. One-fifth of this cohort (18.1%; 110/609) had unknown fellowship training: they either reported no fellowship (13.6%; 83/609) or did not specify the type of training (4.4%; 27/609). Shoulder and elbow fellowship-trained surgeons performed more TSA (median: 89.0 TSA per surgeon between 2012 and 2014) than surgeons without shoulder and elbow fellowship training (median: 67.0 TSA per surgeon; $P < 0.001$). More than one-third (37%) of shoulder and elbow fellowship-trained surgeons' surgical case volume was comprised of TSA, with an additional 35% from non-arthroplasty shoulder procedures (**Figure 2**). In order for the current supply of shoulder and elbow fellowship-trained surgeons to meet the Medicare TSA demand, each fellowship graduate would have to perform 140.6 TSA in Medicare patients annually. Shoulder and elbow fellowship-trained surgeons were more likely to practice in referral regions with an increased Medicare population ($P < .001$), an increased number of

surgeons performing TSA ($P < .001$), and a higher proportion of Medicaid-eligible patients ($P = .01$; **Table 4**). Shoulder and elbow fellowship-trained surgeons (18.7 years post-medical school graduation) were also earlier in their careers than other consistent TSA surgeons (23.1 years post-graduation; $P < .001$).

DISCUSSION

Utilization of TSA has continued to rise; however, access to this cost-effective procedure was recently demonstrated to be limited.¹¹ In a separate analysis, we established the continued rise in use of TSA in the Medicare population, coupled with an increase in the number of surgeons routinely performing TSA.² Multiple analyses have demonstrated the importance of high-volume surgeons and hospitals familiar with the intricacies of shoulder arthroplasty concepts in minimizing complications, improving the quality and decreasing the cost of TSA.^{6,10,17} Specifically, Singh and colleagues¹⁸ demonstrated from a multi-center registry that surgeons and hospitals with greater shoulder arthroplasty volumes had decreased intra-operative blood loss, operative time, and hospital length of stay. As the demand for TSA, both anatomic and reverse, continues to rise, it is imperative that the healthcare delivery system is optimized to provide the best possible care. Before we can determine whether specialized training in shoulder arthroplasty influences surgical outcomes, characteristics and training of surgeons performing TSA should be described.

The number of surgeons performing >10 TSA in the Medicare population rose significantly between 2012 and 2014 (29.3%). However, the number of TSAs per surgeon over this time period remained consistent (approximately 25 per surgeon). Furthermore, the increase in the number of surgeons performing a reportable volume of TSA by 2014 was from the addition of already active surgeons (ie, the growth in TSA was not from the addition of newly trained arthroplasty surgeons but originated from the existing orthopedic surgeon workforce). In a recently published analysis, Somerson and colleagues,¹¹ using this same dataset, demonstrated persistent limitations in access to high-volume TSA surgeons. In a more recent analysis, we showed that while still lacking for some patients, access to a high-volume TSA surgeon has improved significantly over the past 3 years, with 96.9% of the United States population residing within 200 kilometers of a high-volume TSA surgeon (>20 Medicare cases).² This analysis validates those findings, with the caveat that the average annual volume per surgeon is not increasing. What remains unknown, due to limitations of this dataset, is how many surgeons are not identified because they are performing ≤ 10 TSA each year or are performing TSA in non-Medicare patients.

With the specialization of healthcare delivery, specifically in orthopedics, it is imperative that mechanisms for providing specialty-focused care be established. However, the proportion of their practice that surgeons dedicate to TSA was unknown. This study demonstrates that this proportion is increasing. Including non-arthroplasty procedures, more than half (58%) of the procedures performed by this surgeon cohort were shoulder-specific. Furthermore, this analysis demonstrates that surgeons performing TSA have significant case diversity, including nearly half of the cohort performing TKA. Repeated evidence has demonstrated the effect of case volume on improved outcomes following orthopedic procedures.^{8,19-21} The pre-existing location-based model for delivering orthopedic care supports case diversity; however, this model continues to be challenged with high-volume centers of excellence and patient travel.²²⁻²⁴ Hip and knee arthroplasty experienced a similar surge in demand, with a subsequent shift in care to high-volume surgeons and centers.²⁵ Shoulder and elbow fellowship-trained surgeons would need to nearly quadruple their current Medicare TSA volume to meet the entire current demand for TSA in the Medicare population (and this does not account for TSA performed by very low-volume surgeons not included in this cohort). With increased utilization of TSA, policymakers and the orthopedic community must determine the structure of delivery (centers of excellence or medium-volume disseminated throughout the country) that is optimal.

For those surgeons consistently performing TSA over the study period, fellowship training was diverse. While the current focus in orthopedics is on case volume, research in other specialties, namely general surgery, has provided repeated evidence that surgical specialization (more so than high case volume) provides improved outcomes.²⁶⁻²⁹ Furthermore, Leopold and colleagues³⁰ demonstrated an inverse relationship between competency in performing a procedure and confidence in one's ability to do so. In their study, educational intervention provided improved competency in the procedure. Less than one-third (29.8%) of TSA in this cohort were performed by a shoulder and elbow fellowship-trained surgeon consistently performing this procedure. Approximately another quarter (26.2%) were performed by consistent TSA surgeons trained in sports surgery. Meanwhile, 34.6% of TSA in this study cohort were performed by a surgeon who did not consistently meet the minimum threshold in all study years (16,435 TSA; 22.8%) or by a surgeon performing TSA without fellowship training (8,489 TSA; 11.8%). There has been a trend toward orthopedic subspecialty training with an increased demand for fellowship-trained surgeons.³¹ Despite this and the complexities of TSA, many continue to be performed by surgeons with an inconsistent volume and those without arthroplasty-specific fellowship training. The available evidence supports a push toward the fellowship-trained, high-volume TSA surgeon in providing reproducible high-quality shoulder arthroplasty care. For now, that surgeon is more likely to be earlier in his/her career and reside in large, referral-based centers surrounded by other surgeons performing TSA.

These findings must be considered in the light of the study limitations. First, this is a large publicly available database. While this type of database provides a unique opportunity to assess the geographic distributions and characteristics of orthopedic surgeons, specifically those performing TSA, it completely prevents any assessment of the relationship between these findings and quality. As such, while the reader may generate hypotheses regarding the implications of our findings on the quality of TSA delivery, the true effects cannot be determined. In the same vein, for the purpose of privacy, surgeons performing ≤ 10 TSA were not included in this dataset. This limitation prevents the identification of low-volume TSA surgeons. Also, it is likely that the observed increase in surgeons over time is likely a reflection of small increases in volume for surgeons already performing TSA. Lastly, a web-based search was undertaken to identify surgeons' self-reported fellowship training. The results of this web-based search could not be validated, and it is possible that fellowship training, or the lack thereof, was mischaracterized and simply not obtainable through a web-based search. Furthermore, it is not possible to fully assess the extent of high-quality TSA training in these various fellowships.

CONCLUSION

In just the past decade, the utilization of TSA in the Medicare population has increased significantly. However, this increase was not achieved by the addition of highly specialized, high-volume surgeons but by the addition of many surgeons performing lower numbers of TSA surgeries. Furthermore, for those performing this cost-effective procedure, TSA constitutes a relatively small proportion of the surgeries they perform. Shoulder and elbow fellowship-trained surgeons currently account for a low percentage of the overall number of surgeons performing TSA. The implications of these findings must be considered and investigated.

Key Info

Key Info:

Take-Home Points

- Between 2012 and 2014, 1,374 surgeons performed >10 total shoulder arthroplasties (TSA) in Medicare patients in at least one year.
- From 2012 to 2014, the number of surgeons performing at least 10 TSA in Medicare patients increased from 834 to 1,078, while the number of TSA increased from 21,137 (25.3 per surgeon) to 26,765 (24.9 per surgeon).
- Many of these surgeons had a diverse surgical practice, with nearly one-half performing total knee arthroplasty, one-third performing non-arthroplasty knee surgeries, and >80% performing non-arthroplasty shoulder procedures.
- Only one-third of these surgeons had formal fellowship training specific to shoulder and elbow.
- In order for the current supply of shoulder and elbow fellowship-trained surgeons to meet the Medicare TSA demand, each currently practicing fellowship graduate would have to perform 140.6 TSA in Medicare patients annually.

Figures/Tables

Figures / Tables:

[zmistowski1218_f1.jpg](#)



Figure 1. Case profile categorized by anatomic region and arthroplasty vs non-arthroplasty for all surgeons reporting >10 total shoulder arthroplasties in a year between 2012 and 2014.

[zmistowski1218_f2.jpg](#)



Figure 2. Profile of cases categorized by anatomic region and arthroplasty vs non-arthroplasty for all shoulder and elbow fellowship-trained surgeons with >10 total shoulder arthroplasties in every year from 2012 to 2014.

Table 1. Trends in the Number of Providers Performing TSA between 2012 and 2014*

	2012	2013	2014	Total
Providers (no.)	1141	1373	1543	1994
Physicians	834	984	1,078	1,374
Non-physicians	307	389	465	620
TSA (no.)	28,022	32,641	37,298	97,961
Physicians	21,137	23,971	26,865	71,973
Non-physicians	6,885	8,670	10,433	25,988
TSA per provider	24.5	23.8	24.2	49.2

Physicians	25.3	24.3	24.9	52.4
Non-physicians	22.4	22.3	22.4	41.2
Procedures (no.)	210,845	224,123	227,305	662,273
Physicians	152,862	160,114	160,851	473,827
Non-physicians	57,983	64,009	66,454	188,446
Procedure per provider	114.4	116.8	116.5	332.13
Physicians	115.9	118.9	118.9	344.9
Non-physicians	110.7	111.9	111.1	303.9
Active providers (no.)	1843	1919	1951	1994
Physicians	1319	1347	1353	1374
Non-physicians	524	572	598	620

* Included are the number of arthroplasties and total procedures over time among this cohort. The number of active providers, determined by billing Medicare for office or surgical procedures within that year, is reported.

Abbreviation: TSA, total shoulder arthroplasty.

Table 2. Case Volumes over Time with All Procedures Categorized by Anatomic Region and Arthroplasty vs Non-arthroplasty*

	2012	2013	2014	Total
Shoulder arthroplasty	21,351 (n=837)	24,128 (n=984)	26,902 (n=1,078)	72,381 (n=1,374)
23472: total shoulder arthroplasty	21,137 (n=834)	23,971 (n=984)	26,865 (n=1,078)	71,973 (n=1,374)
23470: Hemiarthroplasty	214 (n=14)	84 (n=6)	37 (n=2)	335 (n=15)
Shoulder (non-arthroplasty)	65,947 (n=887)	68,746 (n=942)	67,642 (n=932)	202,335 (n=1,102)
29826: arthroscopic acromioplasty	19,152 (n=724)	20,367 (n=760)	20,495 (n=754)	60,014 (n=908)
29827: arthroscopic rotator cuff repair	14,700 (n=613)	15,963 (n=664)	16,426 (n=658)	47,089 (n=809)
23412: open rotator cuff repair	1957 (n=88)	2046 (n=90)	2112 (n=2,112)	6115 (n=143)
23430: Open biceps tenodesis	4063 (n=178)	3998 (n=167)	4601 (n=185)	12,662 (n=288)
29823: arthroscopic major debridement	7428 (n=301)	7745 (n=309)	5202 (n=210)	20,375 (n=417)
Total knee arthroplasty	25,640 (n=565)	26,558 (n=587)	25,675 (n=580)	77,873 (n=637)
Total hip arthroplasty	8729 (n=316)	9226 (n=318)	9367 (n=330)	27,322 (n=382)
Trauma	6454 (n=260)	6396 (n=254)	6364 (n=261)	19,214 (n=410)

27245: surgical treatment of broken thigh bone (intertrochanteric)	2602 (n=162)	2654 (n=164)	2537 (n=160)	7793 (n=274)
27236: surgical treatment of broken thigh bone (hemiarthroplasty)	1961 (n=123)	1703 (n=111)	1702 (n=112)	5366 (n=205)
Hand	6343 (n=139)	7321 (n=154)	8006 (n=172)	21,670 (n=211)
Elbow	6113 (n=198)	6139 (n=204)	6131 (n=198)	18,383 (n=270)
Knee (non-arthroplasty)	8514 (n=275)	8140 (n=275)	7689 (n=230)	24,343 (n=374)
Outpatient visits	879,740 (n=1,282)	907,124 (n=1,320)	921,291 (n=1,327)	2,708,155 (n=1,342)
New patient	195,898 (n=1,276)	192,937 (n=1,305)	191,427 (n=1,315)	571,203 (n=1,332)
Existing patient	740,307 (n=1,279)	714,187 (n=1,316)	729,864 (n=1,324)	2,29,976 (n=1,338)

* Procedures of interest with high case volumes are reported individually.

Table 3. A Representation of Fellowships Among TSA Surgeons and Their Shoulder Arthroplasty Case Load*

Fellowship	Surgeons (%)	2012-2014 (no, %)	SA Medicare Cases (%)	Average Surgeon Annual SA Volume
Shoulder and elbow	191 (31.4%)	21,444 (38.6%)	29.3%	37.4
Hand surgery	76 (12.5%)	6971 (12.6%)	17.1%	30.6
Sports	223 (36.6%)	18,899 (34.0%)	19.4%	28.3
Trauma	14 (2.3%)	1270 (2.3%)	10.9%	30.2
Adult reconstruction	32 (5.3%)	2485 (4.5%)	10.2%	25.9
Unknown/none	110 (18.1%)	8489 (15.3%)	16.3%	25.7
1 Fellowship	459 (75.3%)	42,065 (75.7%)	20.7%	30.5
≥2 Fellowships	67 (11.0%)	7122 (12.8%)	22.5%	35.4

* Not all fellowships (eg, oncology) included due to small numbers. Also, many surgeons performed multiple fellowships.

Abbreviations: SA, shoulder arthroplasty; TSA, total shoulder arthroplasty.

Table 4. Breakdown of Geographic Characteristics of Orthopedic Surgeons Consistently

Performing TSA between 2012 and 2014 Stratified by Fellowship Training

Abbreviations: HRR, hospital referral region; TSA, total shoulder arthroplasty.

Fellowship	Percentage in Non-Urban Area	Average No. of Other TSA Surgeons within HRR	Median Proportion of Patients Eligible for Medicaid within HRR	Average Proportion of Caucasian Patients within HRR	Average Population in Practicing Zip Code	Average No. of Medicare Beneficiaries in HRR	Average No. Years from Medical School Graduation
Shoulder and elbow	7.3%	10.5	12.6	84.7	26,620.1	224,868.3	18.7
Other fellowships	10.3%	8.6	11.1	85.6	27,619.7	177,939.7	23.1
<i>P</i> value	0.29	<0.001	0.01	0.30	0.41	<0.001	<0.001
Hand surgery	7.9%	8.1	12.8	83.7	24,022.8	179,370.8	23.9
Sports	11.2%	8.9	11.9	85.6	28,588.9	185,902.4	21.2
Trauma	21.4%	7.7	13.8	85.5	20,065.9	170,807.6	25.6
Adult reconstruction	6.3%	8.7	12.8	86.9	26,601.5	173,280.1	22.4
None/unknown	10.9%	8.5	12.0	86.4	28,173.6	166,522.5	27.0

References

References

1. Kim SH, Wise BL, Zhang Y, Szabo RM. Increasing incidence of shoulder arthroplasty in the United States. *J Bone Joint Surg Am.* 2011;93(24):2249-2254. doi:10.2106/JBJS.J.01994.
2. Zmistowski B, Padegimas EM, Howley M, Abboud J, Williams G, Namdari S. Trends and Variability in

- the Use of Total Shoulder Arthroplasty for Medicare Patients. *J Am Acad Orthop Surg*. 2018;26(4):133-141. doi:10.5435/JAAOS-D-16-00720
3. Day JS, Lau E, Ong KL, Williams GR, Ramsey ML, Kurtz SM. Prevalence and projections of total shoulder and elbow arthroplasty in the United States to 2015. *J Shoulder Elbow Surg*. 2010;19(8):1115-1120. doi: [http://www.jshoulderelbow.org/article/S1058-2746\(10\)00110-2/abstract](http://www.jshoulderelbow.org/article/S1058-2746(10)00110-2/abstract).
 4. Day JS, Paxton ES, Lau E, Gordon VA, Abboud JA, Williams GR. Use of reverse total shoulder arthroplasty in the Medicare population. *J Shoulder Elbow Surg*. 2015;24(5):766-772. doi:10.1016/j.jse.2014.12.023.
 5. Schairer WW, Nwachukwu BU, Lyman S, Craig EV, Gulotta LV. National utilization of reverse total shoulder arthroplasty in the United States. *J Shoulder Elbow Surg*. 2015;24(1):91-97. doi:10.1016/j.jse.2014.08.026.
 6. Westermann RW, Pugely AJ, Martin CT, Gao Y, Wolf BR, Hettrich CM. Reverse shoulder arthroplasty in the United States: A comparison of national volume, patient demographics, complications, and surgical indications. *Iowa Orthop J*. 2015;35:1-7.
 7. Acevedo DC, Mann T, Abboud JA, Getz C, Baumhauer JF, Voloshin I. Reverse total shoulder arthroplasty for the treatment of proximal humeral fractures: patterns of use among newly trained orthopedic surgeons. *J Shoulder Elbow Surg*. 2014;23(9):1363-1367. doi: [http://www.jshoulderelbow.org/article/S1058-2746\(14\)00036-6/abstract](http://www.jshoulderelbow.org/article/S1058-2746(14)00036-6/abstract).
 8. Hammond JW, Queale WS, Kim TK, McFarland EG. Surgeon experience and clinical and economic outcomes for shoulder arthroplasty. *J Bone Joint Surg Am*. 2003;85-A(12):2318-2324.
 9. Jain NB, Kuye I, Higgins LD, Warner JJP. Surgeon volume is associated with cost and variation in surgical treatment of proximal humeral fractures. *Clin Orthop Relat Res*. 2012;471(2):655-664. doi:10.1007/s11999-012-2481-6.
 10. Lyman S, Jones EC, Bach PB, Peterson MGE, Marx RG. The association between hospital volume and total shoulder arthroplasty outcomes. *Clin Orthop Relat Res*. 2005;(432):132-137. doi:10.1097/01.blo.0000150571.51381.9a.
 11. Somerson JS, Stein BA, Wirth MA. Distribution of high-volume shoulder arthroplasty surgeons in the United States: Data from the 2014 Medicare provider utilization and payment data release. *J Bone Joint Surg Am*. 2016;98(18):e77. doi:10.2106/JBJS.15.00776.
 12. Fisher ES, Bell J-E, Tomek IM, Esty AR, Goodman DC. Trends and regional variation in hip, knee, and shoulder Replacement. Atlases and Reports. Dartmouth Atlas of Health Care. <https://www.dartmouthatlas.org/atlasses-and-reports/>. Accessed December 14, 2018.
 13. Daniels AH, DiGiovanni CW. Is subspecialty fellowship training emerging as a necessary component of contemporary orthopaedic surgery education? *J Grad Med Educ*. 2014;6(2):218-221. doi:10.4300/JGME-D-14-00120.1.
 14. Department of Health and Human Services, Centers for Medicare and Medicaid Services. Physician and other supplier Data 2012 CY 2012. <https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Tren...> Published October 5, 2015. Accessed July 25, 2016.

15. The Dartmouth Institute for Health Policy and Clinical Practice. Dartmouth Atlas of Health Care. Understanding the Efficiency and Effectiveness of the Health Care System. <http://www.dartmouthatlas.org/>. Accessed January 31, 2014.
16. United States Department of Commerce. United States Census Bureau. 2010 Census Urban and Rural Classification and Urban Area Criteria. <https://www.census.gov/geo/reference/ua/urban-rural-2010.html>. Accessed September 30, 2016.
17. Kempton LB, Ankerson E, Wiater JM. A complication-based learning curve from 200 reverse shoulder arthroplasties. *Clin Orthop Relat Res*. 2011;469(9):2496-2504. doi:10.1007/s11999-011-1811-4.
18. Singh A, Yian EH, Dillon MT, Takayanagi M, Burke MF, Navarro RA. The effect of surgeon and hospital volume on shoulder arthroplasty perioperative quality metrics. *J Bone Joint Surg Am*. 2014;23(8):1187-1194. doi:10.1016/j.jse.2013.11.017.
19. Jain N, Pietrobon R, Hocker S, Guller U, Shankar A, Higgins LD. The relationship between surgeon and hospital volume and outcomes for shoulder arthroplasty. *J Bone Joint Surg Am*. 2004;86(3):496-505.
20. Taylor HD, Dennis DA, Crane HS. Relationship between mortality rates and hospital patient volume for Medicare patients undergoing major orthopaedic surgery of the hip, knee, spine, and femur. *J Arthroplasty*. 1997;12(3):235-242. doi:10.1016/S0883-5403(97)90018-8.
21. Walch G, Bacle G, Lädermann A, Nové-Josserand L, Smithers CJ. Do the indications, results, and complications of reverse shoulder arthroplasty change with surgeon's experience? *J Bone Joint Surg Am*. 2012;21(11):1470-1477. doi:10.1016/j.jse.2011.11.010.
22. FitzGerald JD, Soohoo NF, Losina E, Katz JN. Potential impact on patient residence to hospital travel distance and access to care under a policy of preferential referral to high-volume knee replacement hospitals. *Arthritis Care Res*. 2012;64(6):890-897. doi:10.1002/acr.21611.
23. Maradit Kremers H, Salduz A, Schleck CD, Larson DR, Berry DJ, Lewallen DG. Referral bias in primary total knee arthroplasty: retrospective analysis of 22,614 surgeries in a tertiary referral center. *J Arthroplasty*. doi:10.1016/j.arth.2016.08.014.
24. Robinson JC, MacPherson K. Payers test reference pricing and centers of excellence to steer patients to low-price and high-quality providers. *Health Affairs*. 2012;31(9):2028-2036. doi:10.1377/hlthaff.2011.1313
25. Laucis NC, Chowdhury M, Dasgupta A, Bhattacharyya T. Trend toward high-volume hospitals and the influence on complications in knee and hip arthroplasty. *J Bone Joint Surg Am*. 2016;98(9):707-712. doi:10.2106/JBJS.15.00399.
26. Anwar S, Fraser S, Hill J. Surgical specialization and training-its relation to clinical outcome for colorectal cancer surgery. *J Eval Clin Pract*. 2012;18(1):5-11. doi:10.1111/j.1365-2753.2010.01525.x.
27. Snow BW, Catwright PC, Young MD. Does surgical subspecialization in pediatrics provide high-quality, cost-effective patient care? *Pediatrics*. 1996;97(1):14-17.
28. Smith J a. E, King PM, Lane RHS, Thompson MR. Evidence of the effect of 'specialization' on the management, surgical outcome and survival from colorectal cancer in Wessex. *Br J Surg*.

2003;90(5):583-592. doi:10.1002/bjs.4085.

29. Hall BL, Hsaio EY, Majercik S, Hirbe M, Hamilton BH. The impact of surgeon specialization on patient mortality: Examination of a continuous Herfindahl-Hirschman Index. *Ann Surg.* 2009;249(5):708-716. doi: 10.1097/SLA.0b013e3181a335f8.

30. Leopold SS, Morgan HD, Kadel NJ, Gardner GC, Schaad DC, Wolf FM. Impact of educational intervention on confidence and competence in the performance of a simple surgical task. *J Bone Joint Surg Am.* 2005;87(5):1031-1037. doi:10.2106/JBJS.D.02434.

31. Morrell NT, Mercer DM, Moneim MS. Trends in the orthopedic job market and the importance of fellowship subspecialty training. *Orthopedics.* 2012;35(4):e555-e560. doi:10.3928/01477447-20120327-13.

Multimedia

Product Guide

Product Guide

- [STRATAFIX™ Symmetric PDS™ Plus Knotless Tissue Control Device](#)
- [STRATAFIX™ Spiral Knotless Tissue Control Device](#)
- [BioComposite SwiveLock Anchor](#)
- [BioComposite SwiveLock C, with White/Black TigerTape™ Loop](#)

×

×

Citation

Benjamin Zmistowski MD William Warrender Michael Livesey BS Alex Girden Gerald R Williams Jr Surena Namdari MSC . The Characteristics of Surgeons Performing Total Shoulder Arthroplasty: Volume Consistency, Training, and Specialization. *Am J Orthop.*

Publish date: December 19, 2018

Benjamin Zmistowski
