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Outpatient versus inpatient total shoulder arthroplasty: A cost and outcome comparison in a comorbidity matched analysis

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ABSTRACT

Background: Previous studies comparing total and reverse shoulder arthroplasty (TSA/RSA) are subject to surgeon selection bias. This study objective is to compare the outcomes and cost of outpatient TSA/RSA to inpatient TSA/RSA.
Methods: 108,889 elective inpatient and outpatient TSA/RSA from Medicare claims data (2016–2018). 90-day readmission and total 90-day costs were compared following propensity score matching.
Results: Younger and healthier patients are receiving outpatient TSA/RSA. Outpatient TSA/RSA was associated with fewer 90-day readmissions (OR 0.48 CI 0.38–0.59, $p < 0.001$) and lower 90-day costs (−20.1% CI -19.1%; −21.1%, $p < 0.001$).
Conclusions: Outpatient TSA/RSA surgery offers lower complication rates and total costs.
Level of evidence: III.

1. Introduction

With an aging population, demand for total and reverse shoulder arthroplasty (TSA/RSA) is growing rapidly.[1] Traditionally performed in the inpatient setting, TSA and RSA are increasingly offered as an outpatient procedure for selected patients. Multiple studies have demonstrated that outpatient (compared to inpatient) TSA/RSA results in a significant cost reduction along with similar to improved complication rates and improved patient satisfaction.[2–7] However, under current reimbursement guidelines from the Centers for Medicare and Medicaid Services (CMS), TSA and RSA are still considered inpatient procedures as they are included in the so-called "inpatient-only" list.[8]

A lack of data on adequate patient selection algorithms represents another barrier to wider implementation as not all patients are suitable candidates for outpatient TSA or RSA. Older and more comorbid patients likely carry elevated risks associated with surgery which merits postoperative observation in an inpatient setting. One recent study has even suggested an age of >70 years to be a contraindication for outpatient TSA/RSA.[9] However, existing studies comparing inpatient to outpatient TSA/RSA lack generalizability and are subject to substantial selection bias as they mainly include single-surgeon or single-institutional data, are limited by small sample sizes and lack proper comorbidity matching.

Using recent national Medicare claims data we therefore aimed to compare inpatient to outpatient TSA/RSA in terms of **1)** patient characteristics (to identify potential surgeon decision-making) and **2)** costs and complications (to assess whether outpatient TSA/RSA is as economic and safe as previous literature would suggest).[2] Finally, **3)** we sought to identify incremental costs associated with various comorbidities in inpatient and outpatient TSA/RSA and specific patient subgroups more likely to benefit from outpatient surgery.

Medicare claims data were used to allow generalizability and sufficient power, and propensity score matching was applied to address selection bias.

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2. Methods

2.1. Data source, study design, and study sample

Data for this retrospective cohort study was extracted from the CMS Limited Data Set.[10] We identified patients who received TSA or RSA surgery in the inpatient or outpatient setting between 2016 and 2018. Cases were defined using international classification of diseases, 10th revision (ICD-10) and current procedural terminology (CPT) codes (Supplementary Table 1). The following exclusion criteria were applied: non-elective procedures, revision procedures, patients under the age of 65 (to ensure Medicare eligibility based on age), diagnosis of fracture, tumor, or septic arthritis, duplicate or incomplete claims, or missing demographic information. Patients were only included if they had continuous enrollment following surgery for 90 days in order to determine 90-day readmissions and costs. Patients with cost data whose values were reported as 'negative', 0, or 3 standard deviations below the mean were also removed as they represent outliers (Fig. 1).

2.2. Study variables

The main effect of interest was TSA/RSA in either the inpatient or outpatient setting. Outpatient surgeries were identified as those with a length of stay (LOS) of 0 days, taking place at a hospital in an outpatient setting or ambulatory surgical center.

Outcomes of interest included complications and cost of care as determined by Medicare payments. Complications included **1)** all-cause readmission within 90 days, **2)** 90-day readmission due to surgical site infection (SSI), pulmonary embolism (PE), deep vein thrombosis (DVT), urinary tract infection (UTI), pneumonia, myocardial infarction (MI), acute kidney injury (AKI), cerebrovascular accident (CVA), and blood transfusion, **3)** Mortality, and **4)** discharge to a skilled nursing facility (SNF). Reasons for readmission were identified using ICD-10 codes (Supplementary Table 2). Cost outcomes were further specified into **1)** Medicare payments related to surgery and hospitalization ('Hospitalization cost'). **2)** 90-day post-discharge cost not including cost of surgery ('90-day post-discharge cost'), **3)** Medicare claims the day of surgery as well as during the 90-day post-discharge period ('Total 90-day cost').

Other study variables were baseline patient demographics (age, race [White, Black, or Other], and gender) and comorbidities (these were defined using ICD-10 codes [Supplementary Table 3] and included the Deyo-Charlson comorbidity index, smoking, obesity (using a cutoff of 35 kg/m2), and type 2 diabetes mellitus [DM] with and without insulin dependence). The latter was singled out from the Deyo-Charlson comorbidity index given its hypothesized clinical relevance in patient selection.

2.3. Statistical analysis

For our first study question, understanding current patient selection

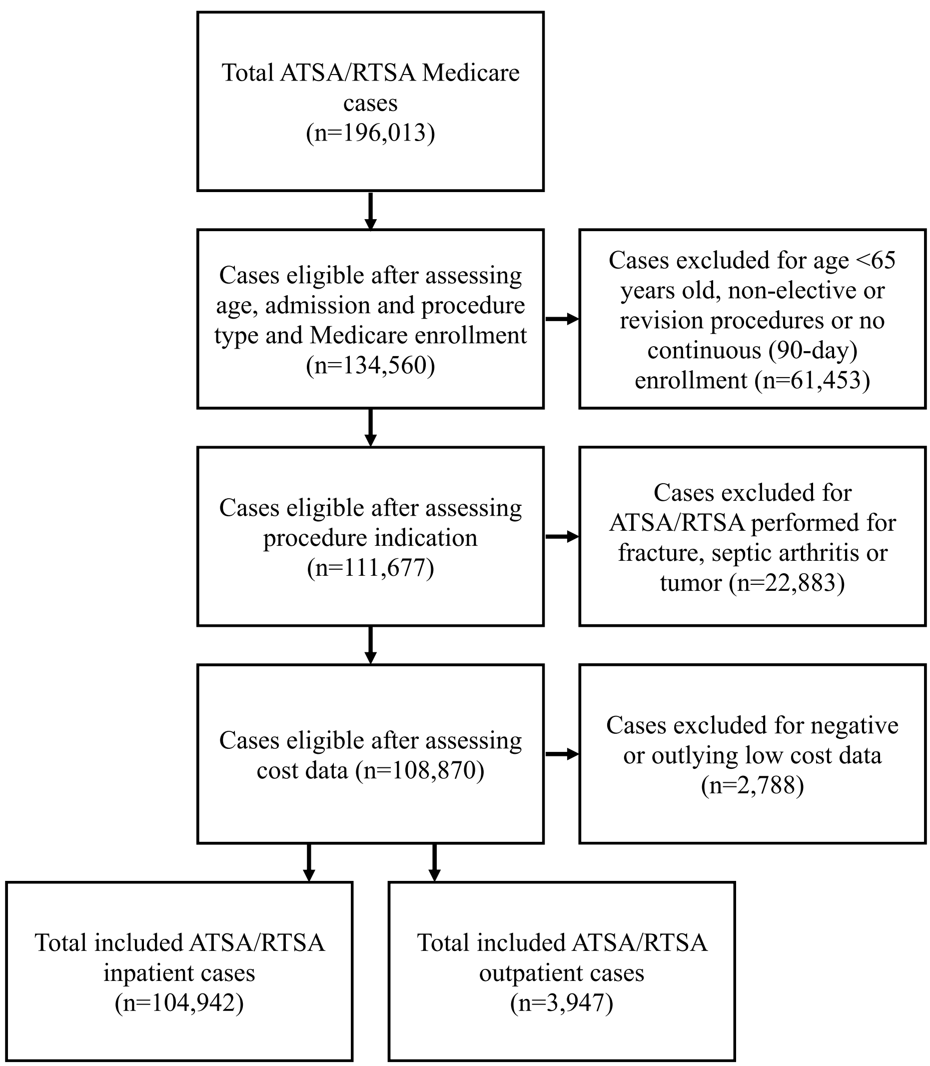

Fig. 1. Medicare dataset flowchart of included and excluded ATSA/RTSA cases performed between 2016 and 2018.

criteria, univariable analysis was used to assess the relationship between the patient characteristics and the location of surgery (Table 1). Given our sample size where these differences easily reach statistical significance, we report both p-values and standardized differences in univariable comparisons. A standardized difference of 0.1 (or 10%) was used to indicate a meaningful difference between groups.

For the main analysis comparing outcomes of cost and complications between the inpatient and outpatient setting, a 1:3 propensity score matching was performed (matching each outpatient case to three inpatient cases). The propensity score was calculated using demographic information, Deyo-Charlson comorbidity index, and the additional comorbidity variables. Standardized differences were recalculated for the matched cohort to ensure proper propensity score matching (Table 2). Using this matched cohort, mixed-effects regression models were applied to compare inpatient and outpatient TSA/RSA in terms of the study outcomes (Table 3). In a further refinement of this analysis we estimated inpatient/outpatient differences in terms of all-cause 90-day readmission, SNF discharge and costs, separately for Deyo-Charlson comorbidity categories 0 to >2 (Table 4). This analysis was performed to evaluate the hypothesized beneficial impact of outpatient surgery across patient comorbidity categories.

We aimed to identify the strongest drivers of 90-day total cost in the inpatient and outpatient setting separately (Table 5). Here, we included patient age, sex and the most common individual comorbidities (smoking, obesity, congestive heart failure, chronic obstructive pulmonary disease, dementia, diabetes mellitus, renal disease, rheumatoid disease and history of a myocardial infarction). Lastly, we analyzed the relationship between medical comorbidities and hospital readmission in the outpatient group separately (Table 6). Throughout, we report odds ratios (OR) with 95% confidence intervals (CI) for the binary outcomes while percent change and 95% CI is reported for the continuous outcomes. Here, we applied the gamma distribution with a log link function (within PROC GLIMMIX in SAS statistical software) as these variables are highly skewed. All analyses were performed using SAS v9.4 statistical software (SAS Institute, Cary, NC).

3. Results

We identified 108,889 patients who received an elective TSA or RSA between 2016 and 2018; 3947 cases (3.6%) were defined as outpatient. Study results are presented separately for each study question.

3.1. *What patient characteristics appear to be used to select patients for outpatient TSA/RSA?*

Overall, patients undergoing outpatient (compared to inpatient) TSA/RSA were younger (71.6 versus 73.0 years old, standardized difference 0.20). They were also more often male (51.3% versus 42.4%, standardized difference 0.18), and generally had a lower comorbidity burden (60.8% versus 52.2% with a Deyo-Charslon comorbidity burden

Table 1
Univariate analysis of unmatched patient demographics and comorbidities.

Variables	Inpatient (N)	Inpatient (%)	Outpatient (N)	Outpatient (%)	P-Value	SDD (%)
Age (years)					<0.001	**22.5**
65-70	26,685	25.4	1270	32.2		
70-75	31,180	29.7	1259	31.9		
75-80	26,440	25.2	919	23.3		
80-85	14,543	13.9	355	9.0		
85+	6094	5.8	144	3.7		
Sex					<0.001	**18.0**
Male	44,484	42.4	2025	51.3		
Female	60,458	57.6	1922	48.7		
Race					0.003	6.4
White	99,181	94.5	3694	93.6		
Black	2684	2.6	100	2.5		
Other	3077	2.9	153	3.9		
Charlson Deyo Index					<0.001	**23.3**
0	54,808	52.2	2400	60.8		
1	28,301	27.0	1042	26.4		
2	12,201	11.6	310	7.9		
>2	9632	9.2	195	4.9		
Year of surgery					<0.001	**14.0**
2016	35,290	33.6	1132	28.7		
2017	38,498	36.7	1435	36.4		
2018	31,154	29.7	1380	35.0		
Comorbidities						
Smoking	4408	4.2	189	4.8	0.071	2.8
Obesity	18,230	17.4	501	12.7	<0.001	**13.1**
Hypertension	64,851	61.8	2338	59.2	0.001	5.2
Myocardial Infarction	4953	4.7	170	4.3	0.229	2.0
Congestive Heart Failure	5523	5.3	117	3.0	<0.001	**11.6**
Peripheral Vascular Disease	3809	3.6	100	2.5	<0.001	6.4
Cerebrovascular Disease	1530	1.5	39	1.0	0.015	4.3
Dementia	1325	1.3	20	0.5	<0.001	8.1
COPD	18,721	17.8	546	13.8	<0.001	**11.0**
Rheumatoid Disease	5935	5.7	155	3.9	<0.001	8.1
Mild Liver Disease	944	0.9	20	0.5	0.010	4.7
Severe Liver Disease	49	0.1	0	0.0	0.175	3.1
Renal Disease	9391	9.0	196	5.0	<0.001	**15.7**
End Stage Renal Disease	237	0.2	3	0.1	0.049	3.9
Diabetes without Complications	17,083	16.3	591	15.0	0.029	3.6
Diabetes with Complications	5083	4.8	107	2.7	<0.001	**11.2**
Diabetes Insulin Dependent	3226	3.1	73	1.9	<0.001	7.9
Diabetes Non-Insulin Dependent	18,153	17.3	612	15.5	0.003	4.8

SDD, Standardized difference; COPD, Chronic obstructive pulmonary disease.

Table 2
Univariate analysis of propensity-score matched patient demographics and comorbidities.

Variable	Inpatient (N)	Inpatient (%)	Outpatient (N)	Outpatient (%)	P-Value	SDD (%)
Age					0.911	5.7
65-70	3752	31.7	1269	32.2		
70-75	3750	31.7	1258	31.9		
75-80	2798	23.6	919	23.3		
80-85	1070	9.0	355	9.0		
85+	465	3.9	144	3.7		
Sex					0.876	0.2
Male	6055	51.2	2024	51.3		
Female	5780	48.8	1921	48.7		
Race					0.047	6.4
White	11,198	94.6	3692	93.6		
Black	242	2.1	100	2.5		
Other	395	3.3	153	3.9		
Charlson Deyo Index					0.516	5.1
0	7217	61.0	2400	60.8		
1	3183	26.9	1042	26.4		
2	921	7.8	310	7.9		
>2	514	4.3	193	4.9		
Year of surgery					0.795	2.4
2016	3428	29.0	1132	28.7		
2017	4343	36.7	1435	36.4		
2018	4064	34.3	1378	34.9		
Comorbidities						
Smoking	541	4.6	189	4.8	0.569	1.0
Obesity	1481	12.5	500	12.7	0.792	0.4
Hypertension	7036	59.5	2336	59.2	0.793	0.5
Myocardial Infarction	471	4.0	169	4.3	0.402	1.5
Congestive Heart Failure	333	2.8	117	3.0	0.620	0.9
Peripheral Vascular Disease	268	2.3	100	2.5	0.330	1.7
Cerebrovascular Disease	82	0.7	39	1.0	0.065	3.2
Dementia	51	0.4	20	0.5	0.537	1.1
COPD	1650	13.9	545	13.8	0.842	0.4
Rheumatoid Disease	433	3.7	155	3.9	0.437	1.4
Mild Liver Disease	55	0.5	20	0.5	0.738	0.6
Severe Liver Disease	0	0.0	0	0.0	1.000	0
Renal Disease	531	4.5	196	5.0	0.211	2.3
End Stage Renal Disease	10	0.1	3	0.1	0.873	0.3
Diabetes without Complications	1784	15.1	591	15.0	0.888	0.3
Diabetes with Complications	302	2.6	106	2.7	0.643	0.9
Diabetes Insulin Dependent	210	1.8	73	1.9	0.755	0.6
Diabetes Non-Insulin Dependent	1845	15.6	611	15.5	0.879	0.3

SDD, Standardized Difference; COPD, Chronic obstructive pulmonary disease.

Table 3
Propensity-score matched analysis of outcomes and cost variables between inpatient and outpatients ATSA/RTSA cases.

Outcomes	Inpatient (N)	Inpatient (%)	Outpatient (N)	Outpatient (%)	P-Value	Odds Ratio	95% Confidence Interval	
All Cause Readmission within 90 days	573	4.8	93	2.4	**<0.001**	0.48	0.38	0.59
Mortality within 90 days	22	0.2	8	0.2	0.833	1.09	0.49	2.45
Blood Transfusion	20	0.2	9	0.2	0.453	1.35	0.62	2.97
Non-Home Discharge	3226	27.3	552	14.0	**<0.001**	0.43	0.39	0.48
Discharge to SNF	898	7.7	25	0.6	**<0.001**	0.08	0.05	0.12
Readmission within 90 days for:								
Surgical Site Infection	25	0.2	5	0.1	0.297	0.60	0.23	1.57
Pulmonary Embolism	36	0.3	7	0.2	0.191	0.58	0.26	1.31
Deep Vein Thrombosis	31	0.3	6	0.2	0.222	0.58	0.24	1.39
Urinary Tract Infection	70	0.6	9	0.2	**0.007**	0.38	0.19	0.77
Pneumonia	50	0.4	11	0.3	0.211	0.66	0.34	1.27
Myocardial Infarction	35	0.3	9	0.2	0.487	0.77	0.37	1.61
Acute Kidney Injury	88	0.7	23	0.6	0.297	0.78	0.49	1.24
Cerebrovascular Accident	20	0.2	1	0.0	0.064	0.15	0.02	1.12
Cost variables	**Inpatient (Mean ± SD)($)**		**Outpatient (Mean ± SD)($)**		**P-value**	**Cost difference (%)**	**95% Confidence Interval**	
Hospitalization Cost ($)	14,896 ± 3854		12,296 ± 4591		**<0.001**	−17.5	−18.3	−16.6
90-Day Post-Discharge Cost ($)	1234 ± 5513		598 ± 3641		**<0.001**	−15.7	−23.7	−7.0
90-Day Total Cost ($)	16130 ± 6835		12894 ± 6178		**<0.001**	−20.1	−21.1	−19.1

SNF, Specialized nursing facility.

Table 4
Propensity-score matched analysis between inpatient and outpatient cases categorized in Charlson-Deyo comorbidity index categories.

	Deyo 0				Deyo 1				Deyo 2				Deyo >2			
Outcomes	Odds Ratio	95% CI		P-Value	Odds Ratio	95% CI		P-Value	Odds Ratio	95% CI		P-Value	Odds Ratio	95% CI		P-Value
All Cause Readmission within 90 days	0.49	0.36	0.67	**<0.001**	0.42	0.27	0.65	**<0.001**	0.87	0.45	1.58	0.656	0.40	0.19	0.85	0.017
Mortality within 90 days	1.00	0.27	3.70	1.000	1.80	0.43	7.56	1.000	6.02	0.54	66.77	0.144	<0.01	<0.001	1.000	0.997
Discharge to SNF	0.07	0.03	0.13	**<0.001**	0.01	0.05	0.19	**<0.001**	0.13	0.05	0.35	**<0.001**	0.08	0.03	0.27	**<0.001**
Cost Variables	**Cost Diff (%)**	**95% CI**		**P-Value**	**Cost Diff (%)**	**95% CI**		**P-Value**	**Cost Diff (%)**	**95% CI**		**P-Value**	**Cost Diff (%)**	**95% CI**		**P-Value**
Hospitalization Cost ($)	−17.9	−19.0	−16.7	**<0.001**	−17.4	−19.0	−15.7	**<0.001**	−17.8	−20.8	−14.7	**<0.001**	−17.6	−21.5	−13.5	**<0.001**
90-Day Post-Discharge Cost ($)	−10.3	−20.9	1.6	0.088	−19.0	−32.8	−2.3	**0.027**	26.1	−10.2	77.0	**0.180**	−39.7	−61.1	−6.6	**0.024**
Total 90-day Cost ($)	−19.9	−21.1	−18.6	**<0.001**	−20.2	−22.0	−18.3	**<0.001**	−18.3	−22.0	−14.5	**<0.001**	−23.2	−27.7	−18.4	**<0.001**

SNF, Specialized nursing facility.

of 0), standardized difference 0.23). Inpatient/outpatient differences in terms of individual comorbidities were most pronounced for obesity (12.7% versus 17.4%), congestive heart failure (CHF; 3.0% versus 5.3%), chronic obstructive pulmonary disease (COPD; 13.8% versus 17.8%), renal disease (5.0% versus 9.0%) and diabetes (DM) with complications (2.7% versus 4.8%); all $p < 0.0001$ and with standardized differences >0.1 (Table 1).

3.2. *To what extent is outpatient (compared to inpatient) TSA/RSA as safe and more economic?*

Propensity score matching resulted in a more balanced distribution of variables between groups (Table 2) as reflected by non-significant p-values and standardized differences <0.1.

Outpatient (compared to inpatient) TSA/RSA was associated with decreased odds of all-cause 90-day readmission (OR 0.48: 95% CI: 0.38–0.59, $p < 0.0001$), and readmission with a diagnosis code for UTI (OR 0.38: 95% CI: 0.19–0.77, $p = 0.007$). No differences were observed for readmission due to DVT, PE, MI, AKI, transfusion, pneumonia, SSI or 90-day mortality. Lastly, outpatient (compared to inpatient) TSA/RSA was associated with decreased odds of discharge to a SNF (OR 0.08: 95% CI: 0.06–0.12, $p < 0.0001$); Table 3.

Outpatient (compared to inpatient) TSA/RSA was associated with a 17.5% reduction in hospitalization cost (CI: 16.6%–18.3%; $p < 0.0001$), a 15.7% reduction in total 90-day post-discharge cost (CI: 7%–23.6%; $p < 0.0001$), and a 20.1% reduction in total 90-day cost (19.1%–21.1%; $p < 0.001$), This translated to a mean per-case cost saving of $2600, $637, and $3236 respectively; Table 3.

3.3. *Subgroup analyses stratified by Deyo-Charlson comorbidity index*

Among patients with a Deyo-Charlson comorbidity index of 0 and 1, outpatient TSA/RSA surgery was associated with lower all-cause 90-day readmission; this effect was absent among patients with a Deyo-Charlson comorbidity index score of ≥2. Outpatient TSA/RSA surgery was associated with lower rates of SNF discharge across all Deyo-Charlson comorbidity groups. A similar pattern was observed in terms of total 90-day cost. Table 4.

Which comorbidities are the strongest drivers of increased cost in inpatient and outpatient TSA/RSA and which patient subgroups should be avoided in outpatient TSA/RSA?

For inpatient TSA/RSA, all studied comorbidities except for smoking were associated with significantly increased total 90-day cost per patient. The largest 90-day increase was seen for patients with a history of CHF which added on average $1397 per patient, followed by age >85 (+$1072), and history of renal disease (+$806). Table 5. For outpatient TSA/RSA all comorbidities except for smoking and diabetes were found to be significant drivers of increased 90-day total cost with CHF (+$1125) representing the largest increase in cost per patient of all the comorbidities, followed by age >85 (+$885) and renal disease (+$676). (Table 5).

In the outpatient TSA/RSA group, smokers (OR 2.24 CI: 1.05–4.77, p-value = 0.037), diabetic patients (OR 2.27 CI:1.42–3.61, p-value <0.001) and patients aged 80–85 (OR 3.46 CI: 1.75–6.85, p-value<0.001) had higher 90-day all cause readmission rates (Table 6).

4. Discussion

Using data on >100,000 patients undergoing TSA/RSA surgery we were able to demonstrate benefits of outpatient (compared to inpatient) surgery across nearly all comorbidity groups. However, readmission risk benefits were specifically pronounced in patients with the lowest comorbidity burden. We also identified the most important cost drivers among inpatient and outpatient RSA/TSA.

Outpatient TSA/RSA holds potential at improving efficiency, increasing patient satisfaction while reducing overall healthcare

Table 5
Significant drivers of total 90-day cost in the inpatient and outpatient setting.

Variables	Reference	Reference Mean Cost ($)\	Cost Difference ($)	Cost Difference (%)	95% CI		P-Value
A. Inpatient							
Age (years)							
70-75	65–70	15,922	242	1.5	1.0	2.1	**<0.001**
75-80			364	2.3	1.7	2.8	**<0.001**
80-85			620	3.9	3.2	4.6	**<0.001**
85+			1073	6.7	5.8	7.7	**<0.001**
Sex							
Female	Male	16,283	−81	−0.5	−0.9	−0.1	**0.014**
Comorbidities							
Smoking	–	16,260	−71	−0.4	−1.4	0.5	0.378
Obesity	–	16,177	417	2.6	2.1	3.1	**<0.001**
Congestive Heart Failure	–	16,157	1397	8.7	7.7	9.6	**<0.001**
COPD	–	16,159	417	2.6	2.1	3.1	**<0.001**
Dementia	–	16,242	738	4.6	2.8	6.4	**<0.001**
Diabetes Mellitus	–	16,244	−118	−0.7	−1.2	−0.2	**0.006**
Renal Disease	–	16,150	806	5.0	4.3	5.7	**<0.001**
Rheumatoid Disease	–	16,243	157	1.0	0.1	1.2	**0.025**
Myocardial Infarction	–	16,216	485	3.0	2.0	3.9	**<0.001**
B. Outpatient							
Age (years)							
70-75	65–70	12,735	217	1.7	1.2	2.2	**<0.001**
75-80			316	2.5	1.9	3.1	**<0.001**
80-85			544	4.3	3.6	5.0	**<0.001**
85+			885	7.0	6.0	7.9	**<0.001**
Sex							
Female	Male	12,876	−28	−0.2	−0.6	0.2	0.283
Comorbidities							
Smoking	–	12,884	−54	−0.4	−1.4	0.6	0.396
Obesity	–	12,838	360	2.8	2.3	3.3	**<0.001**
Congestive Heart Failure	–	12,884	1126	8.7	7.8	9.7	**<0.001**
COPD	–	12,877	343	2.7	2.1	3.2	**<0.001**
Dementia	–	12,887	633	4.9	3.1	6.8	**<0.001**
Diabetes Mellitus	–	12,878	−84	−0.7	−1.2	−0.1	**0.014**
Renal Disease	–	12,858	676	5.3	4.5	6.0	**<0.001**
Rheumatoid Disease	–	12,885	145	1.1	0.3	2.0	**0.010**
Myocardial Infarction	–	12,896	376	2.9	2.0	3.9	**<0.001**

Table 6
Multivariate analysis of risk factors for 90-day all cause readmission in the outpatient setting.

Variables	Reference	Odds ratio	95% CI		P-Value
Age (years)					
70-75	65–70	1.62	0.90	2.91	0.107
75-80		1.73	0.93	3.23	0.084
80-85		3.46	1.75	6.85	**<0.001**
85+		2.08	0.68	6.31	0.194
Sex					
Female	Male	1.03	0.68	1.57	0.887
Race					
Black	White	0.37	0.05	2.66	0.320
Other		1.26	0.45	3.54	0.661
Comorbidities					
Smoking	–	2.24	1.05	4.77	**0.037**
Obesity	–	1.07	0.58	1.97	0.832
Congestive Heart Failure	–	1.62	0.62	4.26	0.330
COPD	–	0.84	0.45	1.57	0.589
Dementia	–	<0.001	<0.001	1	0.927
Diabetes Mellitus	–	2.27	1.42	3.61	**<0.001**
Renal Disease	–	1.41	0.66	3.04	0.378
Rheumatoid Disease	–	1.93	0.82	4.56	0.132
Myocardial Infarction	–	1.06	0.41	2.74	0.903

costs.[2,6,11–13] However, reliable, and generalizable data is necessary to demonstrate safety. We have found, surgeons are selecting younger, healthier, and male patients, a conclusion in line with previous literature.[13] More specifically, surgeons tended to select against patients with COPD, CHF and patients with complications stemming from DM. Despite this, nearly 14% of the outpatient group had a history of COPD, and almost 3% had diabetes with end-organ damage, comorbidities considered either high risk or absolute contraindications.[9,14] Interestingly, surgeons did not appear to select out smokers, and smokers were found to be at higher readmission risk, consistent with a previous study.[15]

Our analysis confirmed that even after controlling for patient comorbidity, age and demographics, outpatient TSA/RSA was associated with a lower all-cause readmission rates and significantly lower costs than inpatient TSA/RSA in terms of hospitalization cost, post-surgical costs and 90-day total cost (a 20.1% reduction translating to a mean per-patient savings of $3236). With arthroplasty growing at a rate of 10–15% per annum, this translates to significant potential savings for the Medicare system.[16,17] In subgroup analyses, we found, the improvement in readmission rate (associated with outpatient surgery) was lost in our sicker cohorts (i.e. those with a Deyo-Charlson score of ≥2). Consistent with multiple papers demonstrating these medical comorbidities are associated with worse outcomes in TSA.[14,15,18–20]

Increasingly it is necessary to understand the costs and risks associated with individual patient comorbidities to maintain economic viability for surgeons, especially if bundle based episodic care payments are initiated. Recent proposals to revise the Medicare hospital outpatient prospective payment system (OPPS) and the Medicare ambulatory surgical center (ASC) payment have been put forward.[21] If proposed changes are implemented, such as the removal of the "inpatient only" procedure list, significant changes with regards to delivery of care as well as reimbursement for shoulder arthroplasty can be anticipated. Having a better understanding of drivers of risk and cost will be essential to ensuring a sustainable practice.

To maintain equitable access to care, surgeons and payers must account for the elevated medical risk and cost some patients pose the system. Our analysis demonstrates smokers, diabetic patients, and patients aged 80–85 all had increased 90-day readmission rates relative to our standardized controls. Of note, while our 80–85 age group experienced a higher readmission rate, our 85+ age group did not. We believe statistical significance was not obtained due to the small number of patients in this group, and that if the numbers had been larger, the same trend in higher readmission rate would be seen in this group as well.

In the inpatient setting, nearly every comorbidity studied was a significant driver of increased cost. History of CHF, age >85, and a history of renal produced the largest increase in cost. Likewise, in our outpatient group as the same 3 comorbidity groups represented the largest risk factors for increased cost. The exclusion of these patient comorbidities due to elevated cost profiles from outpatient consideration is consistent with a recent study which eliminates these groups from outpatient TSA consideration based on elevated medical risk.[9] In our opinion, because these comorbidities are associated with such a significant increase in cost, in addition to a higher rate of adverse outcomes, patients with these comorbidities would likely require risk adjustments in a potential bundle or should be excluded from future bundled payment models altogether to maintain equitable access to care.

After comorbidity matching patients and removing the cost of the surgery and initial hospitalization, patients performed in the outpatient setting demonstrated a 15.7% reduction in 90-day post-discharge cost. We postulate that this additional cost savings may be due to lower utilization rates of inpatient rehabilitation services. Our data suggests routine post-operative hospital admissions likely increase SNF utilization even if it may not be medically necessary, representing a significant increase in cost to the system. We also hypothesize that higher SNF utilization may be at least partially responsible for the higher 90-day readmission rate seen among our inpatient group which was present even after propensity matching patient comorbidities. Additional research is needed to definitively state why comorbidity matched patients have higher SNF discharge. It is possible that this may be a result of lack of social support at home which is not identified appropriately preoperatively. In order to expand outpatient TSA, these patients must be appropriately identified, and home accommodations made preoperatively.

As we transition from a fee-for-service to value-based care models, identifying patient populations which can be safely performed in an outpatient setting will be crucial to improve value-based metrics. We believe studies such as ours which utilize large databases represent an objective and data-driven approach to identify potential patient selection algorithms for outpatient shoulder arthroplasty.

5. Limitations

The limitations of our study include the inherent limitations of most database studies, including unknown disease severity, anesthesia protocols, and post-operative rehabilitation methodology. In addition, our results are based on the quality of provider coding and identification of specific complications via the ICD-10 coding system. Also, there are additional confounding variables inherent to patient selection for outpatient surgery which are not represented in the Medicare database and therefore not included in this study. These factors include things such availability of ambulatory surgery centers, anesthesiology indications, as well as regional practice differences. In addition, given the current reimbursement structure of Medicare making it difficult to get these surgeries approved as outpatient events, with inconsistent reimbursement for implants, these surgeries though deemed “outpatient” because patients have an LOS of 0, most are not performed in an ambulatory surgery center but rather in a traditional hospital and thus patients are not truly getting an “outpatient” surgery in the same way outpatient knee arthroplasty is performed. However, as we were seeking to measure all-cause readmission, mortality, and cost variables in a specific population for which this database is entirely inclusive we feel it was the best possible study design to answer our preliminary study questions.

6. Conclusion

We summarize that while there is no substitute for proper clinical judgement in determining patient selection, our data driven analysis is clearly in support of wider indications for outpatient elective shoulder arthroplasty with a recommendation for a comorbidity-based risk adjustment model to any future shoulder arthroplasty bundle to ensure equitable access to care.

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CRediT authorship contribution statement

Andrew Carbone: Methodology, Investigation, Writing – original draft. **Alexander J. Vervaecke:** Methodology, Investigation, Writing – original draft. **Ivan B. Ye:** Software, Formal analysis, Data curation. **Akshar V. Patel:** Data curation, Resources. **Bradford O. Parsons:** Conceptualization, Resources, Writing – review & editing. **Leesa M. Galatz:** Conceptualization, Resources, Writing – review & editing. **Jashvant Poeran:** Software, Investigation, Resources, Writing – review & editing. **Paul Cagle:** Conceptualization, Resources, Writing – review & editing, Supervision.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jor.2021.11.016.

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