Research Article

Lower Socioeconomic Status Is Associated With Worse Preoperative Function, Pain, and Increased Opioid Use in Patients With Primary Glenohumeral Osteoarthritis

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Abstract

Background: Numerous studies have identified differences in patient-reported outcome scores and complication rates based on various measures of socioeconomic status (SES); however, there is limited information regarding the role of SES in the shoulder arthroplasty cohort. The purpose of this study was to characterize the role of SES in patients undergoing primary anatomic total shoulder arthroplasty (TSA) for primary glenohumeral osteoarthritis (OA).
Methods: We identified 1,045 patients who had primary TSA done for OA in a prospective shoulder arthroplasty registry, and 982 patients met inclusion criteria. We prospectively assessed patient demographics, comorbidities, patient-reported outcome scores, range of motion, and preoperative opioid use. Each patient was assigned to a quartile according to the Area Deprivation Index using their home address as a measure of SES.
Results: The most disadvantaged patients (lower SES) reported to our center with a higher body mass index and higher rates of preoperative opioid use and diabetes. Patients in the most disadvantaged quartile reported more preoperative pain (Constant—Pain and American Shoulder and Elbow Surgeons [ASES]—Pain) and lower function (Constant—ADL, Constant—Total, and ASES). Multivariate regression identified that male patients and advanced age at surgery had better reported ASES pain scores, while preoperative opioid use, chronic back pain, and the most disadvantaged quartile were associated with worse ASES pain scores.
Conclusion: Lower SES correlates with worse preoperative function and pain in patients undergoing anatomic TSA for primary glenohumeral OA. Providers should be cognizant of the potential impact of SES when evaluating quality metrics for patients with primary glenohumeral OA.
Level of Evidence: Level 3, cross-sectional study.

The social determinants of health care have been studied in numerous fields, including orthopaedic surgery. Numerous studies in the hip and knee arthroplasty literature have identified differences in patient-reported outcome scores (PROs) and complication rates based on various measures of

socioeconomic status (SES).[1–5] However, there is scant literature examining the role of SES in the shoulder arthroplasty cohort.

Socioeconomic status should be of interest for multiple reasons. For one, evolving payment models for total joint arthroplasty in the United States have heightened interest in identifying factors that influence PROs. In addition, the elective nature of shoulder arthroplasty may pose a challenge to patients with limited access to care. It is therefore conceivable that patients of lower SES present with worse function and more pain than patients of higher SES. Understanding the impact of SES on preoperative PROs could be important in patient prognostication or risk stratification given studies in the hip and knee arthroplasty literature demonstrating a strong correlation between preoperative functional scores and clinical outcomes.[6–8] Moreover, understanding the impact of SES on orthopaedic patients can also be useful for primary care physicians and other referring providers.

Various tools for measuring SES have been reported in the literature, including broad groups of insurance type (Medicare/Medicaid versus private),[9–11] questionnaires about socioeconomic parameters,[1] and zip code–based indices of only the Medicare cohort.[2] Zip code–based indices of SES have been validated and used in healthcare research around the world. The Area Deprivation Index (ADI) is a relatively new database available in the United States that provides a numerical ranking for the socioeconomic deprivation of neighborhoods based on the domains of income, education, employment, and housing quality.[12] In comparison with insurance type (Medicare/Medicaid versus private), the ADI provides a more holistic, quantitative, and graded representation of SES. The ADI can be easily obtained through a patient's address and includes all the United States rather than only the Medicare cohort.

The purpose of this study was to characterize the role of SES in patients undergoing primary anatomic total shoulder arthroplasty (TSA) for primary glenohumeral osteoarthritis (OA). Specifically, we sought to characterize preoperative differences in demographics, comorbidities, opioid usage, function, and pain among patients with different levels of SES as determined by the ADI. We hypothesized that patients with lower SES would have worse preoperative function and pain, a higher number of comorbidities, and higher preoperative opioid usage.

Methods

Patient Inclusion Criteria and Demographics

We identified 1,045 patients in a prospective shoulder registry that underwent primary anatomic TSA for the treatment of primary glenohumeral arthritis (OA) and who had a residential address on file. We excluded 52 patients because their listed address was a PO Box in a town with more than one nine-digit zip code and 11 international patients because it was not possible to use the ADI in these two circumstances. The final study cohort was 982 patients. All the patients were enrolled in the registry at a single, high-volume shoulder arthroplasty center by the senior author (T.B.E.) before surgery.

The ADI is a validated index constructed from 17 poverty, education, housing, and employment factors derived from the 2013 American Community Survey. The index uses census block level data to construct an index value for neighborhoods throughout the United States and Puerto Rico.[13,14] Neighborhoods can then be ranked by SES and used to evaluate health outcomes and policy, especially for the most disadvantaged neighborhood groups.[13–18]

The national ADI rank was obtained for each patient by placing the patient's address into an online database organized by nine-digit zip code (https://www.neighborhoodatlas.medicine.wisc.edu).[12] Patients were then stratified in quartiles based on ADI for analysis. The first quartile included the most disadvantaged patients (ADI range 62 to 100), second quartile (range 39 to 61), third quartile (range 22 to 38), and the fourth quartile included the least disadvantaged patients (range 1 to 21).

Patient demographic and clinical characteristics were prospectively assessed and included age, sex, insurance type (Medicare/Medicaid versus private), smoking status, body mass index (BMI), history of chronic back pain, depression, diabetes, and heart disease. Preoperative opioid use was determined prospectively by asking: "Do you take narcotic pain medication (codeine or stronger) for your shoulder—yes or no?".[19,20] The Constant score,[21] the American Shoulder and Elbow Surgeons (ASES) score,[22] the Single Assessment Numeric Evaluation,[23] and range of motion measurements were assessed preoperatively for all patients.

Clinical Assessment

All patients were enrolled in a shoulder arthroplasty outcomes registry before surgery. The senior author (T.B.E.) done all examinations in a standardized fashion.[24] Range of

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motion measurements were determined using a goniometer. Strength of abduction was measured using a handheld digital dynamometer (Chatillon Digital Force Gauge 90.72 kilogram-force; AMETEK).

Statistical Analysis

Patients were grouped according to the ADI into quartiles for statistical analysis: most disadvantaged quartile (lower SES), second quartile, third quartile, and least disadvantaged quartile (higher SES). Analysis of variance with Bonferroni post hoc tests was used to compare patient demographic and clinical characteristics (age at surgery, BMI, pain, and function) between ADI groups. Chi-squared tests were done to determine whether notable differences existed between the ADI groups for comorbidities such as smoking status, history of opioid use, chronic back pain, depression, diabetes, or heart disease. Multivariate, stepwise regression techniques were used to identify notable predictors of ASES and ASES pain scores from patient demographic and clinical characteristics. Statistical analyses were done with Stata release 15 (StataCorp LLC), and all differences were considered statistically significant if $P < 0.05$.

Results

There were no statistical differences between the ADI quartiles for demographic factors (Table 1) such as sex, age at surgery, and dominant shoulder (all $P > 0.05$). BMI was significantly higher in the most disadvantaged as compared to the third (31.6 ± 6.5 versus 29.6 ± 5.5, $P = 0.006$) and least disadvantaged quartiles (31.6 ± 6.5 versus 28.7 ± 5.4, $P < 0.001$), while the second quartile was significantly higher than the least disadvantaged quartile (30.5 ± 5.8 versus 28.7 ± 5.4, $P = 0.001$). Similarly, the most disadvantaged and second quartiles had more preoperative opioid use due to shoulder pain (31.3% and 31.1%, respectfully) than the third and least disadvantaged quartiles (19.8% and 21.5%, respectfully; all $P < 0.05$). Diabetes was more prevalent in the most disadvantaged quartile as compared to the third (18.5% versus 12.1%, $P = 0.048$) and least disadvantaged quartiles (18.5% versus 7.7%, $P < 0.001$). There were no statistical differences in the rate of smoking, chronic back pain, depression, and heart disease between ADI quartiles (all $P > 0.05$).

Patient pain and function were evaluated according to ADI quartile (Table 2). The most disadvantaged quartile reported significantly worse Constant pain scores than the third (2.9 ± 2.6 versus 3.8 ± 2.8, $P = 0.002$) and least disadvantaged quartiles (2.9 ± 2.6 versus 4.4 ± 3.1, $P < 0.001$). In addition, the second quartile patients reported significantly more pain on the Constant scale as compared to the least disadvantaged quartile (3.5 ± 3.0 versus 4.4 ± 3.1, $P = 0.002$). Activities of daily living were significantly more difficult for the most disadvantaged (6.6 ± 3.8) and second quartile patients (7.1 ± 3.6) as compared to the least disadvantaged quartile (8.3 ± 4.0, $P < 0.001$ and $P = 0.002$). The total Constant and adjusted Constant scores were significantly lower in the most disadvantaged quartile as compared to the least disadvantaged quartile ($P = 0.016$ and $P = 0.025$, respectfully). ASES measures showed a similar trend to Constant scores. The most disadvantaged quartile had worse ASES pain scores than the third (6.4 ± 2.6 versus 5.7 ± 2.7, $P = 0.021$) and least disadvantaged quartiles (6.4 ± 2.6 versus 5.5 ± 2.7, $P = 0.002$). The total ASES score was significantly lower in the most disadvantaged quartile as compared to the third (31.7 ± 18.1 versus 38.4 ± 18.1, $P < 0.001$) and least disadvantaged quartiles (31.7 ± 18.1 versus 39.8 ± 19.3, $P < 0.001$).

Multivariate regression techniques were used to identify notable predictors of ASES pain and total ASES scores from patient demographic and clinical characteristics (Table 3). Factors associated with less pain included male sex ($\beta = -0.5$, $P = 0.003$) and age at surgery ($\beta = -0.2$, $P = 0.012$) [per 10 years]. Three factors were associated with worse pain scores: preoperative opioid use ($\beta = 0.7$, $P < 0.001$), chronic back pain ($\beta = 0.7$, $P < 0.001$), and patients in the most disadvantaged quartile ($\beta = 0.6$, $P = 0.005$). Factors predicting total ASES scores followed a similar trend with an increase in ASES score for male patients ($\beta = 4.6$, $P < 0.001$). Four factors were associated with lower ASES scores: BMI ($\beta = -0.3$, $P = 0.001$), preoperative opioid use ($\beta = -5.6$, $P < 0.001$), chronic back pain ($\beta = -6.0$, $P < 0.001$), and patients in the most disadvantaged quartile ($\beta = -5.2$, $P = 0.001$).

Discussion

The results of this study support our hypothesis that patients of lower SES undergoing primary anatomic TSA for glenohumeral OA have worse preoperative function and pain, higher rates of opioid usage, and a higher rate of diabetes mellitus. In addition, lower SES was correlated with higher BMI. We also identified a trend toward higher rates of chronic back pain, depression, and heart disease based on lower SES.

Previous studies have investigated the role of SES on PROs,[11] length of stay,[25] complications,[9] and revision rates.[25] Each of these studies measured SES by broad groups of insurance type. Schoch et al demonstrated that Medicare or Medicaid insurance in patients younger than 65 years correlates with lower preoperative and postoperative function and pain scores after shoulder arthroplasty compared with patients with private

Table 1

Subject Characteristics

Factor	Most Disadvantaged Quartile	Second Quartile	Third Quartile	Least Disadvantaged Quartile	*P*
Number	249	238	248	247	NA
Male sex (%)	149 (59.8%)	145 (60.9%)	156 (62.9%)	156 (63.2%)	0.850
Age at surgery (yr) mean ± SD	67.1 ± 10.4	66.5 ± 10.0	66.4 ± 9.3	67.1 ± 9.2	0.782
Dominant shoulder	115 (46.2%)	116 (48.7%)	128 (51.6%)	120 (45.6%)	0.689
BMI mean ± SD	31.6 ± 6.5[a]	30.5 ± 5.8[b]	29.6 ± 5.5	28.7 ± 5.4	<0.001
Current smoker	13 (5.4%)	10 (4.3%)	10 (4.1%)	6 (2.5%)	0.665
Preoperative opioid use	78 (31.3%)[a]	74 (31.1%)[c]	49 (19.8%)	53 (21.5%)	0.002
Chronic back pain	98 (39.4%)	75 (31.5%)	90 (36.3%)	74 (30.0%)	0.105
Depression	33 (13.3%)	28 (11.8%)	33 (13.3%)	18 (7.3%)	0.116
Diabetes	46 (18.5%)[a]	30 (12.6%)	30 (12.1%)	19 (7.7%)	0.004
Heart disease	26 (10.4%)	23 (9.7%)	29 (11.7%)	14 (5.7%)	0.115

BMI = body mass index
[a] Most disadvantaged quartile markedly different than least disadvantaged and third quartiles.
[b] Second quartile markedly different than least disadvantaged quartile.
[c] Second quartile markedly different than the least disadvantaged and third quartiles.

Table 2

Subject Pain and Function Measures

Factor	Most Disadvantaged Quartile	Second Quartile	Third Quartile	Least Disadvantaged Quartile	*P*
Constant—Pain	2.9 ± 2.6[a]	3.5 ± 3.0[c]	3.8 ± 2.8	4.4 ± 3.1	<0.001
Constant—ADL	6.6 ± 3.8[b]	7.1 ± 3.6[c]	7.4 ± 3.9	8.3 ± 4.0	<0.001
Constant—ROM	10.2 ± 8.3	10.3 ± 7.6	10.5 ± 7.6	11.2 ± 8.0	0.526
Constant—Strength	3.7 ± 6.4	4.0 ± 6.5	3.7 ± 6.6	3.7 ± 6.4	0.917
Constant—Total	23.4 ± 15.9[b]	24.8 ± 15.6	25.4 ± 15.3	27.7 ± 16.1	0.025
Constant—Adjusted	30.3 ± 20.3[b]	31.7 ± 19.0	32.6 ± 18.9	35.5 ± 19.9	0.031
ASES	31.7 ± 18.1[a]	35.6 ± 18.7	38.4 ± 18.1	39.8 ± 19.3	<0.001
ASES—Pain	6.4 ± 2.6[a]	6.0 ± 2.7	5.7 ± 2.7	5.5 ± 2.7	0.002
SANE	32.5 ± 26.3	33.1 ± 24.0	34.5 ± 24.1	33.0 ± 22.2	0.801
Forward flexion	76.6 ± 37.5	80.5 ± 36.5	81.6 ± 37.1	84.9 ± 35.6	0.124
External rotation	12.3 ± 14.1	10.6 ± 13.9	9.7 ± 14.0	10.6 ± 14.7	0.241

ASES = American Shoulder and Elbow Surgeons; ROM = range of motion; SANE = Single Assessment Numeric Evaluation
[a] The most disadvantaged group markedly different than least disadvantaged and third quartile groups.
[b] The most disadvantaged group markedly different than the least disadvantaged group.
[c] The second quartile group markedly different than the least disadvantaged group.

insurance.[11] Matsen et al[25] showed that Medicaid insurance is associated with longer hospital stays and revision rates after shoulder arthroplasty. Li et al[9] demonstrated that Medicare or Medicaid/uninsured patients were more likely to have medical and surgical perioperative complications after shoulder arthroplasty than age- and sex-matched patients with private insurance.

The authors of these studies recognized the shortcomings of using broad groups of insurance type as surrogates for SES because there may be other explanations for having nonprivate insurance other than SES alone. For

Table 3

Multivariate Regression Predicting ASES—Pain and Total ASES Scores

	ASES—Pain		ASES	
Factor	**β (95% CI)**	***P***	**β (95% CI)**	***P***
Male sex	−0.5 (−0.9 to −0.2)	0.003	4.6 (2.2 to 6.9)	<0.001
Age at surgery (per 10 yrs)	−0.2 (−0.4 to −0.05)	0.012	—	—
BMI	—	—	−0.3 (−0.5 to −0.1)	0.001
Preoperative opioid use	0.7 (0.3 to 1.1)	<0.001	−5.6 (−8.3 to −3.0)	<0.001
Chronic back pain	0.7 (0.4 to 1.1)	<0.001	−6.0 (−8.3 to −3.5)	<0.001
Most disadvantaged quartile	0.6 (0.2 to 0.9)	0.005	−5.2 (−7.8 to −2.5)	0.001
Constant	7.1 (5.9 to 8.4)	<0.001	38.5 (36.2 to 40.8)	<0.001

ASES = American Shoulder and Elbow Surgeons; BMI = body mass index

example, there are many circumstances in which a patient older than 65 years has Medicare insurance without being socioeconomically disadvantaged. Nonetheless, it is certainly more practical to use surrogates for SES than to obtain that information directly from patients.

This is the first study, we are aware of, that uses the ADI to study SES in the shoulder arthroplasty cohort. We have found the ADI to be extremely useful and a better surrogate of SES than zip code alone or insurance status alone. The ADI has numerous advantages compared with insurance type (Medicare/Medicaid versus private). It is a continuous variable with a better ability to differentiate patients and can be easily acquired through only a patient's home address. It is also perhaps a more holistic representation of SES than insurance type because its methodology[13,14] accounts for sociodemographic factors such as income/poverty, education, employment, housing, and occupation. Finally, it can be used in research as a way of comparing group demographics and perhaps as a tool for matching patients. We anticipate that the ADI will continue to be used in the shoulder arthroplasty cohort and in the broader orthopaedic surgery context moving forward.

One notable finding of this study is that SES was directly correlated with preoperative function scores. This is important given several studies in the hip and knee arthroplasty literature that have shown that preoperative function is a strong—and in some studies, the strongest—predictor of postoperative function.[7,8,26] This information may play an important role in risk stratification and prognostication. Moreover, if the findings in our region are validated in other parts of the country, the influence of SES on PROs should be considered in the development of quality measures for shoulder arthroplasty.

There are numerous possible explanations for the association between SES and worse preoperative pain and function. Patients of lower SES may have more difficulty with access to care and may present with more advanced shoulder OA. There could also be differences in opioid-prescribing patterns based on different regions or zip codes. Increased preoperative opioid use in patients of lower SES is notable because several studies have shown that preoperative opioid use is associated with poorer outcomes[19,20] and increased postoperative doctor shopping.[27] Perhaps, targeted education could make this a modifiable risk factor; programs about the detrimental effect of opioids on TSA outcomes can be offered to primary care providers treating symptoms of severe glenohumeral OA in the patient who initially prefers not to be referred for surgery. Despite a trend toward more responsible opioid-prescribing habits, opioids continue to be used for conditions such as OA, and the impacts of opioid usage on orthopaedic patients and society at large have been profound.[27,28] Finally, differences in comorbidities could explain our findings, given that lower SES was associated with higher rates of diabetes and higher BMI along with statistical trends toward higher rates of heart disease, depression, and chronic back pain. Unfortunately, this study is not able to identify an underlying causal explanation.

We acknowledge that there are limitations of our investigation. Limitations include that our data were collected at a single center with a single surgeon. Our high-volume tertiary referral center is in one of the largest cities in the United States and may not be reflective of the patient cohort in the community or in other regions of the United States. In addition, the ADI version we used was based on census data from 2009 to 2013, compared with our registry which was collected from 2004 to 2015; therefore, it may not be perfectly representative of each patient's social deprivation index at

the time surgery. This study is also limited by not assessing the role of SES on 2-year functional outcomes, satisfaction, and complication rates after shoulder arthroplasty. This is an exciting direction for future study. Our focus for this investigation was exclusively assessing the study cohort at time zero (before surgery) to determine the effect of the disease and other variables that may influence preoperative PROs, function, and pain.

This study has several strengths. First, our investigation included a homogenous patient cohort with all patients preparing to undergo TSA to treat primary glenohumeral OA, the most common indication for TSA.[29] Second, given our robust shoulder arthroplasty registry, we were able to account for many variables that may contribute to preoperative function and pain including opioid use, chronic back pain, and depression among others. Finally, although the data are from a single center, this is one of the largest cohorts to date of patients with primary OA undergoing TSA.

Conclusion

Lower SES correlates with worse preoperative function and pain, as well as higher rates of opioid usage, higher BMI, and diabetes mellitus in patients undergoing anatomic TSA for primary glenohumeral OA. The ADI has potential in research to control for the influence of SES on PROs. Surgeons, primary care providers and payers should be cognizant of the potential impact of SES when treating or evaluating quality metrics for patients with primary glenohumeral OA.

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