Research Article

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Trends in Inpatient Resource Utilization and Complications Among Total Joint Arthroplasty Recipients: A Retrospective Cohort Study

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Abstract

Introduction: Joint arthroplasty practice is highly dynamic to adapt to economic changes and advances in medicine. This study provides updates of the current perioperative practice on healthcare resource utilization.

Methods: The study included total knee arthroplasty, total hip arthroplasty, and total shoulder arthroplasty within the healthcare cost and utilization project New York State database from 2007 to 2013 (ie, 202,100, 127,872, and 8858 cases, respectively).

Results: A higher proportion of sicker patients were prevalent over time. The length of stay decreased continuously. However, total hospital charges increased after adjusting for inflation. The incidence of wound infection and transfusion decreased steadily over time, whereas acute renal failure has been on the rise. There was an increased utilization of echocardiography, while decreased among other resources.

Discussion: Total knee arthroplasty, total hip arthroplasty, and total shoulder arthroplasty changed toward sicker patients with shorter length of stay, fewer complications, and less resource utilization. However, overall costs increased over time.

Total joint arthroplasties (TJAs) are among the most commonly performed procedures in the United States and are highly effective by offering improvement in function and overall quality of life.[1,2] With studies projecting 3.48 million total knee arthroplasty (TKA) and 700,000 total hip arthroplasty (THA) procedures per year by 2030, appropriately anticipating resource needs and healthcare costs associated with such an endeavor becomes highly important.[3] Studies have evaluated trends in patient demographics and characteristics undergoing TJA.[2] Similarly, efforts to prognosticate outcomes have led to the identification of comorbidities associated with high inpatient resource utilization.[4] However, little data are available regarding comprehensive time trends for resource utilization and complications in patients undergoing TJA after the introduction of the Affordable Care Act in 2010.

Changes in the methods in which hospitals are reimbursed have renewed interest in the evidence behind cost-effective delivery of care. The inception of value-based systems is an example of a national effort to combat increasing healthcare costs in the face of an aging population. Programs such as the Comprehensive Care for Joint Replacement, which falls under the Centers for Medicare and Medicaid Services' Bundled Payments for Care Improvement initiative, attempt to contain costs without compromising care by linking reimbursements to outcomes and holding healthcare providers accountable for complications and readmissions.[5] However, studies reveal that these value-based bundled payments are often not appropriately adjusted for increased risk and procedural complexities; efforts to do so even with existing evidence are lacking.[6-8] As a result, surgeons are increasingly disincentivized to operate on high-risk patients, and patient access to needed surgery may become restricted. Our intention is to study the trend of practice and challenge the assumption that increased comorbidities may be associated with higher incidence of complications.

In recent years, improvements in surgical approaches and anesthetic techniques have been implicated in reducing inpatient hospital costs and postoperative complications in certain types of joint arthroplasty. For example, unicompartmental knee arthroplasty and anterior approach THA are two such techniques shown to reduce hospital length of stay (LOS) and decrease total cost of hospitalization.[9,10] Similarly, application of regional anesthesia has shown to be associated with decreased resource utilization and complications in both shoulder and lower extremity joint arthroplasty.[11,12]

Conversely, preoperative comorbidities such as frailty, morbid obesity, malnourishment or weight loss, anemia, and pulmonary-circulatory disorders are associated with increased costs and hospital LOS.[13-16] Without risk-adjusted bundled payments, overcoming these and other risk factors associated with higher costs and postoperative complications then become imperative to keep surgeons motivated to provide quality care. Therefore, the purpose of this retrospective cohort study was to analyze the trend of resource utilization and postoperative outcomes in TJA in an effort to understand where improvements might be made to better align the incentives of the healthcare providers with those of insurers. Furthermore, we challenge the assumption that increased comorbidities may be associated with higher incidence of complications.

Methods

This study was exempted by the institutional review board (protocol# 2017-0716).

Study Sample

We acquired the New York State Inpatient Database (SID) from 2007 to 2013 via Healthcare Cost and Utilization Project (HCUP) (http://www.hcup-us.ahrq.gov). HCUP SID data contain all patient information statewide, and they are derived from administrative data originally collected for billing purposes. The database includes patient demographic information, *International Classification of Diseases, Ninth Revision, Clinical Modification* (*ICD-9-CM*) diagnosis and procedure codes, information on discharge, and admission status. The full list of variables included is available online (http://www.hcup-us.ahrq.gov/nisoverview.jsp). We identified all primary TKA (*ICD-9-CM* code 81.54), primary THA (*ICD-9-CM* code 81.51), and primary total shoulder arthroplasty (TSA, *ICD-9-CM* code 81.80). There were 202,100, 127,872, and 8858 cases from 2007 to 2013, respectively.

Study Variables

Variables included patient demographics, such as age, sex, race, LOS, types of anesthesia, Deyo comorbidity index, insurance payer, and hospital charges. Comorbidities were evaluated based on the combination of *ICD-9-CM* codes as described (http://www.hcup-us.ahrq.gov/toolssoftware/comorbidity/Table2-FY12-V3_7.pdf). The events of complications during the hospitalization and

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in-hospital resource utilization were summarized in reference to previous reports.[17,18] The events of complications include wound infection, pneumonia, myocardial infarction (MI), cardiac events other than MI, acute renal failure (ARF), and blood transfusion. The hospital resources include physical therapy (PT), occupational therapy (OT), echocardiography, stress test, chest radiograph, and coronary care unit (CCU) service.

Statistical Analysis

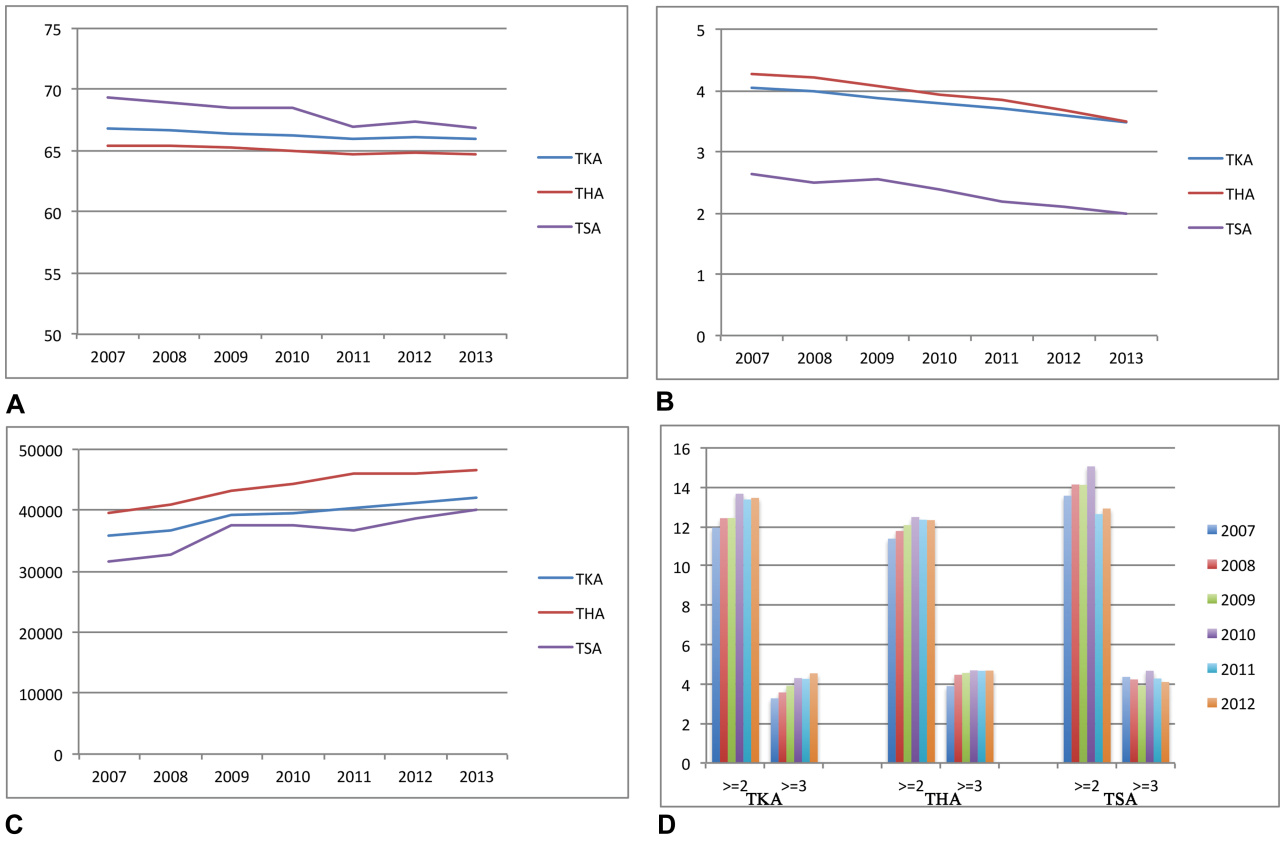
Data analysis was performed using STATA 14.2 statistical software (StataCorp LP) and SAS version 9.4 (SAS Institute). The Student *t*-test was used to analyze continuous variables, such as age. Pearson chi-square tests were applied for categoric variables, such as sex, race, insurance payer, and comorbidities. Trend analyses were performed for each outcome using univariable linear regression with year as the sole predictor to obtain the R^2 value and statistical significance.

Results

We studied all primary TKA, THA, and TSA patients in HCUP/SID-NY database from 2007 to 2013. There were 202,100, 127,872, and 8,858 patients, respectively. The average age of patients for TKA, THA, and TSA remained relatively stable, with a slight trend toward younger age over the study period (Figure 1 and Table 1). For example, the average age for TSA patients was 69.4 ± 10.4 years in 2007 and continuously decreased to 66.9 ± 9.8 by 2013. The slope of age changes was less significant in TKA and THA. More female patients were seen in each category (ie, 64.2% to 66.2% in TKA, 55.3% to 56.4% in THA, and 51.7% to 58.4% in TSA), whereas percentages of male patients increased over time in general. The race mix of patients remained predominantly white. Medicare/Medicaid remained the most common payer over time (ie, 56.1% to 58.8% in TKA, 53.2% to 56.0% in THA, and 62.1% to 68.1% in TSA).

More patients were seen in both TKA and THA groups with higher comorbidity burden as represented

Figure 1



Graphs showing patient characteristics: age (year) (**A**); length of stay (day) (**B**); submitted charges ($) (**C**); and Deyo index (**D**). THA = total hip arthroplasty, TKA = total knee arthroplasty, TSA = total shoulder arthroplasty

Table 1

Summary Statistics of Trend Analysis

	TKA		THA		TSA	
	R^2	*P* Value	R^2	*P* Value	R^2	*P* Value
Age	0.8544	0.0029	0.9303	0.0004	0.883	0.0017
LOS	0.9938	<0.0001	0.9802	<0.0001	0.9468	0.0002
Submitted charges	0.9304	0.0004	0.9203	0.0006	0.7975	0.0068
Deyo index ≥2	0.8373	0.0039	0.8547	0.0029	0.0324	0.6995
Deyo index ≥3	0.9612	0.0001	0.7841	0.0080	0.0934	0.5051
Wound infection	0.88	0.0018	0.8399	0.0037	1	NA
Transfusion	0.9136	0.0008	0.9756	<0.001	0.7851	0.0079
Myocardial infarction	0.632	0.0326	0.0643	0.5832	0.0166	0.7828
Cardiac events other than MI	0.8758	0.0019	0.8346	0.0040	0.1403	0.4079
Pneumonia	0.0526	0.6207	0.0896	0.5144	0.088	0.568
ARF	0.8359	0.0039	0.9128	0.0008	0.0841	0.528
PT	0.5065	0.0729	0.5098	0.0715	0.1123	0.4624
OT	0.5123	0.0705	0.8851	0.0016	0.8817	0.0017
Echocardiogram	0.6522	0.0280	0.7026	0.0185	0.0647	0.5821
Cardiac stress test	0.8815	0.0017	0.6787	0.0227	0.0848	0.5755
Chest radiograph	0.7005	0.0188	0.8006	0.0065	0.2688	0.2332
CCU	0.8091	0.0058	0.5818	0.0461	0.4925	0.0788

ARF = acute renal failure, CCU = coronary care unit, LOS = length of stay, MI = myocardial infarction, NA = not available, OT = occupational therapy, PT = physical therapy, THA = total hip arthroplasty, TKA = total knee arthroplasty, TSA = total shoulder arthroplasty

by a higher Deyo comorbidity index (Figure 1). TSA patients did not present an apparent pattern of changes in respect to the Deyo index. The LOS continuously decreased within each procedure category, with TKA at 4.04 ± 2.36 days in 2007 to 3.47 ± 1.93 days in 2013, THA at 4.26 ± 3.25 days in 2007 to 3.49 ± 2.69 days in 2013, and TSA at 2.65 ± 2.41 days in 2007 to 1.99 ± 1.78 days in 2013. Conversely, total hospital charges increased across all procedure types after adjusting for inflation based on 2007 dollar, with average charges for TKA at $35,721 in 2007 to $41,980 in 2013, THA at $39,575 in 2007 to $46,590 in 2013, and TSA at $31,551 in 2007 to $40,015 in 2013 (Figure 1).

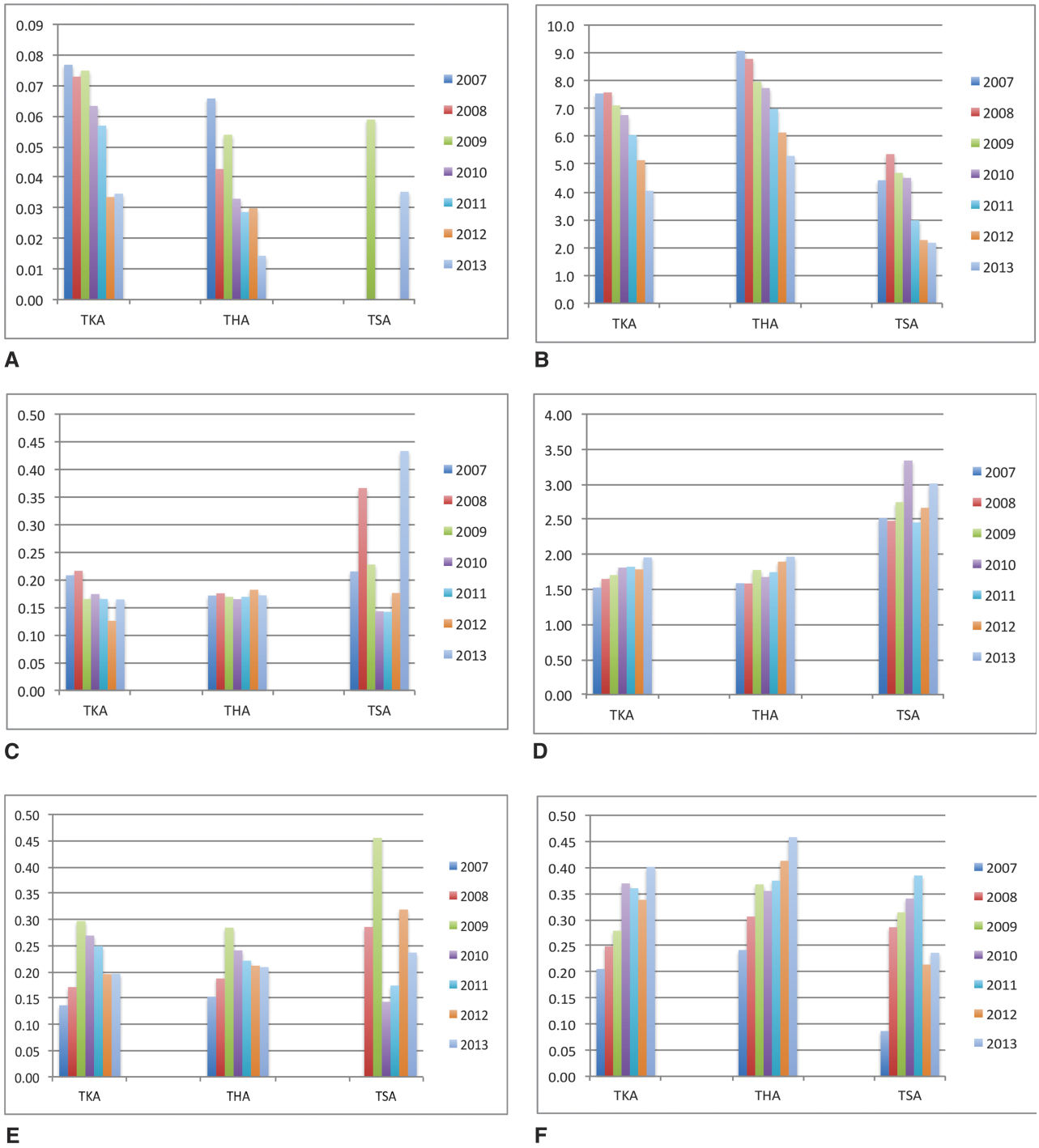
We next analyzed the incidence of complications over time (Figure 2 and Table 1). All complications were adjusted for LOS and reported as complications per in-hospital day. The incidences of two complications continuously decreased for all procedure categories, such as wound infection (from 0.08% per hospital day in 2007 to 0.03% per hospital day in 2013 among TKA patients) and transfusion (from 7.54% per hospital day in 2007 to 4.04% per hospital day in 2013 in TKA) (Table 1). Other complications, including MI, and pneumonia remained largely unchanged from 2007 to 2013. The incidence of cardiac event excluding MI and ARF increased over time. ARF among TKA patients increased from 0.21% per hospital day in 2007 to 0.40% per hospital day in 2013.

The utilization of PT during the hospitalization remained consistently high, higher than 98% in TKA and THA patients and 63.7% to 73.1% among TSA patients (Figure 3). The utilization of occupation therapy increased, especially among THA and TSA patients, from 44.7% in 2007 to 59.7% in 2013 among THA patients (Figure 3 and Table 1). More utilization of echocardiography service was seen over time (Figure 3, from 0.92% to 1.29% in TKA, 1.20% to 1.69% in THA, and 0.10% to 1.02% in TSA). The utilizations of many other resources decreased, including for stress tests, chest radiographs, and CCU care among selective arthroplasty procedures (Figure 3).

Discussion

Our analysis of all primary TKA, THA, and TSA cases collected from 2007 to 2013 in the HCUP/SID-NY database identified notable trends in patients undergoing these procedures. We determined a modest trend toward younger patients in

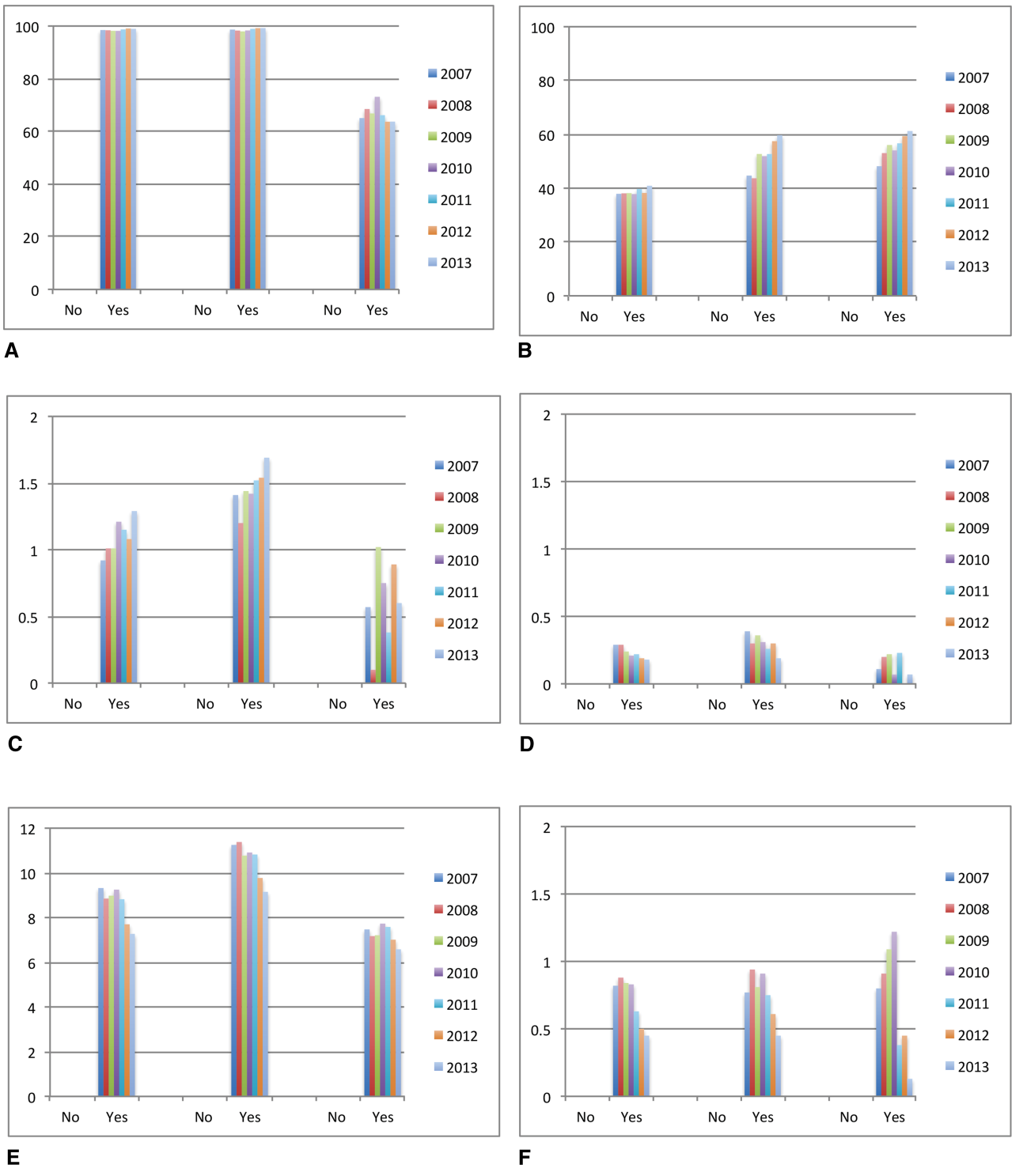
Figure 2



Graphs showing postoperative complications: wound infection (**A**); transfusion (**B**); MI (**C**); cardiac events other than MI (**D**); pneumonia (**E**); and acute renal failure (**F**). MI = myocardial infarction

TKA and THA and more prominent trend among patients undergoing TSA. Furthermore, we found an increased average comorbidity burden over time, as reflected by higher Deyo index scores. Complication rates remained relatively stable or decreased. Utilization of resources and tests was bidirectional with CT, chest radiograph, stress test, and CCU use decreasing and that of echocardiography and OT services increasing.

Figure 3



Graphs showing itemized resource utilization: physical therapy (**A**); occupational therapy (**B**); echocardiogram (**C**); cardiac stress test (**D**); chest radiograph (**E**); and coronary care unit (**F**).

No change in PT utilization was found.

Indications for TJA have expanded to include younger, more active patients,[19-23] and our finding of a trend toward younger patients in primary TKA, THA, and TSA cases is consistent with trends in other patient databases over similar periods.[24,25] The increasing proportion of younger patients seen here has potential implications for healthcare resource utilization because joint bearings intended for younger, more active patients tend to be costlier.[24] Most patients for each of the three procedures were women; an analogous finding in the Veteran population has been attributed to a higher incidence of osteoarthritis in women.[22] We observed a trend toward an increasing percentage of male patients for each of the three procedures, a finding that to our knowledge has not previously been reported. We observed no clear trend in the racial makeup of patients undergoing each of the three procedures.

Our finding of an increased average comorbidity burden in this patient group, as reflected by higher Deyo index scores, for TKA and THA, is consistent with national trends.[2,26] Interestingly, as has been found on a national level for THA,[2] comorbidity burden increased for TKA and THA while simultaneously age decreased. A higher comorbidity burden has been associated with higher costs in THA.[27] Of note, we did observe an increase in inflation-adjusted total hospital submitted charges for each of the three procedures studied. However, we could not identify causes of this increase with the available information in the HCUP database studied (Figure 3). It is likely other factors beyond the scope of our study might be contributing to the increase of such submitted charges. For example, surgeons and hospitals are incentivized to discharge patients earlier and to screen patients to prevent the 30-day readmissions since the Affordable Care Act became effective. Over the past 10 years, more practices have implemented programs that include multimodal analgesia with peripheral nerve blocks, aggressive PT with multiple sessions (two to three times daily), and blood salvage therapy. All these potentially could increase the hospital cost with the aim of facilitating discharge readiness earlier. Because we also identified a downtrending pattern of complications over the years studied, the increase in initial hospital spending could potentially be cost-effective by decreasing high-cost complications. Future research is indicated to better understand what is driving the increase of hospital charges.

We identified stable or reduced rates of complications over the span of our study period. To account for changes in decreasing LOS, we adjusted rates to events per each in-hospital day.[25,28] The incidence of postoperative complications remained overall stable or decreased, with the exception of ARF. Improved perioperative care is likely contributing to these, such as better wound closure techniques, improved wound dressing, the utilization of tranexamic acid, and other blood preservation techniques.[29-31] As the LOS for all procedures also decreased, this raises the question whether the complication burden, particularly for those complications that present several days after joint arthroplasty, was merely shifted to intermediate care facilities such as skilled nursing facilities or acute rehab facilities to which joint arthroplasty patients were discharged.[20,25,28] In an era of intensified focus to shift joint arthroplasty to an outpatient setting, this issue deserves further study because it potentially represents an important patient safety issue.

The reason for an increase in the diagnosis of ARF remains speculative. Since the publication of the RIFLE (Risk, Injury, Failure, Loss of kidney function, and End-stage kidney disease) criteria for acute kidney injury in 2004,[24,32] and the AKIN (Acute Kidney Injury Network) modification in 2007,[32] adoption of these definitions of AKI (acute kidney injury) has been inconsistent across medical societies and, presumably, in clinical care. It is possible that the promulgation of the RIFLE and AKIN criteria during our study period complicated the picture, leading to higher documentation rates. As an essential component of multimodal analgesia, NSAID has been administered more frequently in recent years. Such practice could also lead to an increase in creatinine levels meeting the diagnostic criteria for ARF, although with debatable clinical implications. It is also known that patients with increased comorbid burden are at greater risk of perioperative AKI,[22] and patients in our study period did indeed trend toward a higher Deyo index. However, this does not explain why the incidence of other complications decreased or remained stable during the period.

Despite the suggestion that a higher comorbidity burden may be associated with increased resource utilization,[27] we found a decrease in several metrics (ie, chest radiograph, stress test, and CCU) and stable utilization of PT. We observed an increase in the utilization of echocardiography and OT. We were not able to determine the timing of the utilization of these tests and services during hospitalization. Thus, it remains unclear, for example, whether echocardiography was being performed as part of preoperative testing and then billed as part of the hospitalization. The decrease in the utilization of stress tests and the increase in the use of echocardiography suggest further study into how evolving risk stratification practices for cardiac

patients undergoing noncardiac surgery, or general trends in the utilization of echocardiography,[33] might be affecting resource utilization in joint arthroplasty. One possibility is that the recent promulgation of strict criteria for the appropriate use of cardiac stress testing and the changes in reimbursement policy for cardiac stress tests[34] could have theoretically placed economic pressure on cardiologists to opt for the less restrictive and less expensive tests such as the echocardiogram.

It has been suggested that the use of regional anesthesia in TSA, THA, and TKA is associated with decreased perioperative complications and resource utilization.[12,35] In our analysis, we observed an overall decrease in complications and resource utilization in TSA even without a clear decrease in the use of general anesthesia alone as the anesthetic method, suggesting additional drivers at work other than type of anesthesia.

Interestingly, despite a shorter average LOS across the three procedures studied here, as well as a decrease in the utilization of several common resources as described earlier, total inflation-adjusted hospital submitted charges increased across all three procedures. This trend may just mirror the general trend in increasing healthcare costs brought on by factors such as increased administrative expenditures. Specifically related to orthopaedic surgery, it has been suggested that joint arthroplasty in younger patients is costlier because of the requirement for more "premium" implants that will withstand greater physical activity and have more longevity.[24] In addition it is possible that more resources need to be spent on a given day to facilitate expediting earlier discharge, such as multiple costly PT sessions. However, submitted hospital charges should be seen as an imperfect proxy for actual costs and resource utilization, largely because charges vary from one hospital to another.[25,27] The increase in hospital charges we observed here deserves further elucidation.

Our study is limited by its nature of using secondary data. Administrative codes should not be expected to perfectly capture clinical reality. However, any coding bias is unlikely to markedly change across institutions over the period studied, thus having only a modest effect on our trend analysis. Second, our study focused only on the same hospitalization. Readmissions and postdischarge events were not counted in our study.

Conclusions

We identified several interesting patterns of change over the period studied: a trend toward younger patients with more comorbidities, stable or decreasing incidence of most postoperative complications, shorter LOS, less resource utilization for many processes except echocardiography and OT, and increased inflation-adjusted total hospital submitted charges. Additional studies are indicated to elucidate potential causative factors for these trends. Nonetheless, our study provides vital information for healthcare providers and healthcare policy makers in designing clinical practices, reimbursement policies, and cost-effective healthcare initiatives.

Acknowledgment

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