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Early Postoperative Outcomes of Primary Total Knee Arthroplasty after Solid Organ Transplantation in the United States, 1998-2011

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Abstract

This review of the Nationwide Inpatient Sample (1998-2011) examined trends in solid organ transplant patients who received a total knee arthroplasty (TKA) to determine whether length of stay (LOS), cost, and perioperative complications differed from non-transplant peers. Primary TKA patients (n=5,870,421) were categorized as: (1) those with a history of solid organ transplant (n=6,104) and (2) those without (n=5,864,317). Propensity matching was used to estimate adjusted effects of solid organ transplant history on perioperative outcomes. The percentage of TKA patients with a transplant history grew during the study period from 0.069% to 0.103%. Adjusted outcomes showed patients with a transplant had a 0.44 day longer LOS, \$962 higher cost of admission, and were 1.43 times more likely to suffer any complication (p=0.0002).

Keywords

total knee arthroplasty; solid organ transplant; complication; length of stay; Nationwide Inpatient Sample

INTRODUCTION

Over 500,000 solid organ transplants have been performed in the United States since 1988.¹ In order of most common to least common these include kidney, liver, heart, lung, and pancreas. Increased survival of solid organ transplant patients over the past 30 years has allowed more of these patients to develop osteoarthritis requiring total knee arthroplasty (TKA).²⁻⁵ The increased survival of transplant patients is due to a combination of improvements in surgical technique, immunosuppressive regimens, patient selection, and

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postoperative care.^{2,3} In addition, these patients are subjected to long-term steroid use to prevent organ rejection, placing them at risk for osteonecrosis of the femoral condyle which may require TKA. Increased complication rates status post TKA from immunosuppression and metabolic derangements secondary to organ dysfunction are of high concern for the orthopaedic surgeon.

The current medical literature is limited in regards to outcomes of solid organ transplant patients following TKA. A systematic review of published studies regarding TKA status post solid organ transplant encompassed 51 TKAs in 9 studies.⁶ Klatt et al.⁷ recently reported a high complication rate (9/23; 39.1%) and infections (4/23; 17.3%) in a retrospective review of 23 TKA patients with a history of solid organ transplant. In contrast, Boquet et al. reviewed 16 TKA patients with a history of renal transplant and found no complications. The common limitation in these studies and other studies in the literature is that they rely on relatively small case series. With such low numbers of TKAs, firm conclusions regarding the outcomes of TKA following solid organ transplantation are difficult to determine.

To overcome the low incidence of patients with a history of solid organ transplant who go on to receive a TKA, the present study utilized a large, nationally representative database to retrospectively compare outcomes in these patients with non-transplant peers. The purpose of the present study was to examine annual trends in solid organ transplant patients who receive a TKA and to determine whether length of stay (LOS), cost, and perioperative complications differed between the two groups of patients. We hypothesized that patients with a history of solid organ transplantation would have a significantly greater LOS, cost, and experience more perioperative complications when compared with patients without a history of transplantation following TKA.

METHODS

Data Description

Data were obtained from the Nationwide Inpatient Sample (NIS) for the years 1998-2011.⁸ This study was deemed exempt from review by the institutional review board because the data used in this study were deidentified. The NIS is part of the Healthcare Cost and Utilization Project (HCUP), sponsored by the Agency for Healthcare Research and Quality. It is the largest all-payer inpatient care database that is publicly available in the US containing nearly 8 million records of inpatient stays per year from over 1,000 hospitals, approximating a 20% stratified sample of hospitals in the US (see www.hcup-us.ahrq.gov/nisoverview.jsp for further information). The NIS provides weights that allow for nationally representative estimates. There are over 100 clinical and nonclinical data elements available through the NIS, such as International Classification of Disease, 9th edition (ICD-9-CM) primary and secondary diagnoses and procedures, admission and discharge status, and patient demographics (*e.g.*, sex, age, race, payment source, duration of stay).

Sample selection

Patients who received a primary TKA (ICD-9-CCCM 81.54) from 1998 through 2011 were included in the study (weighted $n=6,350,918$) (Figure 1). The following were sequentially excluded from the study: patients with admission type of emergency, urgent, newborn, trauma center, or other or admission source of emergency room, patients with a primary diagnosis suggestive of prior arthroplasty, patients with malignant neoplasm and/or metastatic cancer, patients with pathologic fractures of the lower extremity, and patients under 18 years old. Appropriate codes were used to identify patients with a transplant of any kind ($n=15,529$) and were removed entirely to create the “non-transplant group” ($n=5,864,317$). Of those 15,529 patients, there were 6,104 primary TKA patients with a history of solid organ transplant [DX: V42.0 (kidney), V42.1 (heart), V42.6 (lung), V42.7 (liver), V42.83 (pancreas)].

Demographic and outcome measures

The annual frequency of primary TKA status post solid organ transplant was estimated using weighted frequencies. Demographics including age, sex, race, primary source of payment, distribution of procedures by hospital size, teaching status, and regional location were estimated. For a large number of cases (approximately 23%), the race category was not available. Comorbidity profiles were analyzed by determining the prevalence of a number of disease states as defined in the Comorbidity Software provided by the Agency for Healthcare Research and Quality⁹. We also examined the trends and comparison between groups in terms of hospital length of stay (LOS), costs per admission, and perioperative complications and adverse events. Costs were calculated by multiplying the total charges by a hospital-specific cost-to-charge ratio provided by HCUP. Frequencies of procedure-related complications were analyzed by determining cases that listed ICD-9-CM diagnosis codes specifying complications of surgical and medical care (diagnosis codes 996.X–999.X). In addition, we studied the prevalence of selected adverse diagnoses using the ICD-9-CM diagnosis codes, including pulmonary embolism (4151%), venous thrombosis (4511%, 4512, 45181, 4519, 4532, 4534%, 4538, 4539), arrhythmia (427), urinary tract infection (5990), and allogenic transfusion using ICD-9-CM procedural codes (9903, 9904, 9905, 9907).

Statistical Analysis—We calculated descriptive statistics for all study variables including annual trends in number of transplant and non-transplant TKA cases, and annual trends in mean total costs and length of stay. Survey weights were applied to all descriptive analysis to present results as U.S. national estimates. Rao-Scott chi square test and simple linear regression were used to test for significant differences in categorical and continuous variables, respectively, between transplant and non-transplant groups. In analysis involving total costs and LOS, the top 0.1% highest values were excluded from the analysis to remove long-tail outliers. Costs were adjusted for inflation based on real GDP chained to 2011 dollars.

To estimate the effect that transplant history has on post-surgical TKA outcomes we used propensity score matching to control for differences in known covariates between groups¹⁰. A propensity score was calculated by creating a logistic model with history of transplant as

the dependent and all of the variables in Table 2 and comorbidities in Figure 2 as the independent variable. The log-transformed predicted value from this model is used to calculate a propensity score for each subject. We then matched subjects in the transplant group with a non-transplant control using a 1:1 optimal matching algorithm based on the linear propensity score. We used a caliper of 0.1 times the standard deviation of the linear propensity score, which resulted in 1,185 unweighted matched pairs (n=2,370), and 60 transplant cases that could not be matched to a control. Survey weights were not used in propensity score analysis because our goal here was not to provide national estimates, but to estimate the average effect of transplant on complication outcomes, costs, and LOS in our study sample. This is known as the average treatment effect among the treated (ATT) approach, where in this case the “treatment” is history of solid organ transplant. To assess covariate balance before and after matching we calculated standardized differences and plotted the absolute values in a dot plot. We compared differences in outcomes between transplant groups using paired t-tests for continuous outcomes, and conditional logistic regression for binary outcomes. All analysis was conducted using SAS software version 9.3 for Unix.

RESULTS

Of the 5,870,421 weighted national estimate of primary TKA patients between 1998-2011, only 6,104 (0.104%) were patients with a history of solid organ transplant (Table 1). This percentage grew from 0.069% in 1998 to 0.103% in 2011, with its highest peak in 2000 (0.135%). The demographics and hospital characteristics of primary TKA patients with a history of solid organ transplant as compared to the non-transplant TKA peers are shown in Table 2. Patients with a history of solid organ transplant tended to be younger at surgery ($p<0.0001$) and male ($p<0.0001$), and were treated at a large ($p<0.0001$), academic ($p<0.0001$), urban hospital ($p<0.0001$) in the West or Midwest ($p<0.0001$). The frequency of each type of solid organ transplant, along with procedure-related complications following primary TKA are shown in Appendix 1.

Patients with a history of transplant had a significantly higher prevalence of hypertension, diabetes (both complicated [$p<0.0001$] and uncomplicated [$p<0.0001$]), deficiency anemia ($p<0.0001$), fluid and electrolyte disorders ($p<0.0001$), rheumatoid arthritis ($p=0.0476$), coagulopathy ($p<0.0001$), and drug abuse ($p=0.0030$) (Figure 2). The prevalence of obesity ($p=0.0007$), hypothyroidism ($p=0.0014$), and chronic pulmonary disease ($p<0.0001$) was significantly lower for solid organ transplant TKA patients when compared to TKA patients without a history of transplant.

The unadjusted trends in mean hospital LOS and cost per admission are shown in Figure 3. Mean overall LOS was higher for patients with a history of solid organ transplant (4.16 days $\pm$ 0.13) than those without (3.65 days $\pm$ 0.02) (<0.0001). Hospital LOS was shown to be trending down for both groups. The overall unadjusted mean total cost per admission were higher for patients with a history of solid organ transplant (\$16,090 $\pm$ 453) than those without (\$14,771 $\pm$ 146) ($p<0.0001$), which trended up for both groups between 2001 and 2011.

Of the perioperative complications included in the study, the only two which showed statistically significant differences between the two groups was infection (i.e. both implant infection or postoperative infection; $p=0.0015$) and the need for a transfusion of blood products ($p<0.0001$) (Table 3). Both were higher in the patients with a history of solid organ transplant (0.64% infection rate, and 17.69% transfusion rate) when compared to the patients without a history of solid organ transplant (0.22% infection rate, 11.65% transfusion rate). It is important to keep in mind that these infection rates are limited to the perioperative hospital stay until discharge.

Propensity score matching led to balance between the transplant and non-transplant groups on patient characteristics (sex, age, race, household income, primary payer source) hospital characteristics (region, bed size, location, surgeon volume, hospital volume) and comorbidities (Figure 4). Outcomes after propensity score adjustment showed that patients with a history of transplant had a 0.44 day longer LOS (95% CI 0.29-0.59) and \$962 higher cost of admission (95% CI \$414-\$1,511) (Table 4). Patients with a history of transplantation were 1.43 times more likely to suffer any complication (95% CI 1.19-1.72; $p=0.0002$), have renal complications including acute renal failure and urinary tract infections (aOR = 1.60; 95% CI 0.13-2.26; $p=0.0099$) and require an allogenic transfusion (aOR = 1.68; 95% CI 1.34 – 2.14; $p<0.0001$). Infection, wound complications, and dislocation were complications included in this study (i.e., Table 3), but due to their low frequency in the database they were not included in the modeling analysis.

DISCUSSION

The primary purpose of this study was to use a large-scale database to describe the annual trends in patients with a history of solid organ transplant, and to compare the outcomes associated with this group with their non-transplant peers. The NIS database provides an opportunity to study the acute postoperative hospitalization period in this highly specialized patient population. These data show that the rate at which these procedures are being performed has increased just over 50% in the years between 1998 and 2011, and that patients with a history of transplantation have a greater LOS, higher costs, and increased complication risks associated with their TKA procedure.

The LOS reported in the present study is similar to that published by Ledford et al.¹¹, which averaged overall 3.7 days for kidney (4.0 days), liver (3.0 days), and lung (3.6 days) transplant patients ($n=19$ total). Some of the smaller case series have reported mean LOS as low as 3.6 days¹² (based on $n=5$) and as high as 7.3 days (± 3.5)¹³ (based on $n=5$).

The limited reports in the literature are dominated by small case series, which focus on the safety of the procedure and generally conclude that TKA following liver¹³, heart¹⁴, lung¹², or kidney¹⁵ transplant is a safe procedure with few complications and successful outcomes. Levitsky et al.¹³ reported on major intraoperative and postoperative complications for 8 TKA procedures in 5 patients with a history of liver transplantation. These patients suffered no major or minor complications other than one patient requiring a blood transfusion. Leonard and Davis¹⁴ presented the outcomes of 4 TKA patients with a history of cardiac transplant. One of these patients experienced a complication of the TKA procedure which

required a knee manipulation. At an average of 54 months follow-up, with a mean functional Knee Society score (KSS) of 79 and objective score of 89. Ledford et al.¹² recently reported on 5 TKAs in 4 patients with a history of lung transplant. Complications in this group included an intraoperative femoral-sided MCL-sleeve avulsion, 4/5 (80%) patients required blood transfusion postoperatively, and 1 patient who became infected at 32 months postoperative. An average functional KSS of 92 and objective score of 92 was reported at an average follow-up of 42.8 months. A series 16 TKAs in 12 patients with a history of renal transplantation was reviewed by Boquet et al.¹⁵ One patient died from septicemia secondary to a mitral valve endocarditis 8 years following the TKA. The remaining 11 patients had excellent functional outcomes at 65 months postop, with an average KSS functional score of 87.7 and objective score of 97.1. No other complications were described.

Two of the larger series of solid organ transplant patients who received a TKA have recently highlighted the increased complication rates associated with this unique subset of patients. Ledford et al.¹¹ reported the results for 21 TKAs performed in patients with a history of kidney (n=12), liver (n=4), and lung (n=5) transplantation at an average follow-up of 41.2 months. The perioperative complication rate was high for this group, which averaged 33% and ranged from 25% in lung recipient patients to 50% in liver recipient patients. In a study of 23 TKAs in 19 patients, the complication rate was 9/23 (39.1%), and included complications such as chronic pain and swelling (requiring revision), quad rupture, femoral stress fracture treated with ORIF, hemarthrosis treated with irrigation and debridement, and arthrofibrosis requiring debridement⁷. All of the complications were in patients who were on immunosuppressant medications.

The increased risk of infection was also highlighted by these larger case series studies. Klatt et al.⁷ reported an infection rate of 4/24 (17.3%), while the rates reported by Ledford et al.¹¹ ranged from 8.3% (kidney patients) to 25% (liver patients). A retrospective case-control study reviewed cases of prosthetic joint infection among transplant recipients, and compared them to non-infected transplant controls¹⁶. Of the 367 total joint arthroplasty patients with a history of solid organ transplant reviewed, 16 cases (4.4%) of infection were identified. In these patients, gram-positive bacteria were the cause of the infection in 8 patients. In the present study, 0.64% of the patients with a solid organ transplant experienced infection prior to discharge, which was significantly higher than that of the control group (0.22%; p=0.0015), consistent with the literature reports of increased infection rates in these immunocompromised patients. It is difficult to fully interpret these results as they are limited to the hospital stay.

The present study showed that patients with a history of solid organ transplant were 1.5 times more likely to require an allogenic transfusion. Ledford et al.¹² reported that of the 20 procedures in patients with a lung transplant prior to a TKA (n=5) or THA (n=15), 10 (50%) procedures required a blood transfusion with an average of 1.9 (range, 1-4) units given. In another study by Ledford et al.¹¹, the transfusion rates for TKA patients with a history of kidney (n=12) and lung (n=5) transplant were high (25% and 80%, respectively), although liver transplant patients (n=4) did not require any transfusions. However, the study by Levitsky et al showed that liver transplant recipients who had a TKA (n=8 procedures) suffered a transfusion rate of 37.5%.

Studies that rely on large, administrative databases have inherent limitations which must be recognized when interpreting the results. Perhaps the most relevant limitation of the NIS data for this study is that it records data from admission to discharge, with no capability of tracking patients beyond discharge. Complication data are limited to the perioperative period, and must be interpreted as such. Reliance on ICD-9 coding can also lead to miscoding and/or undercoding, and may be responsible for contradictory results that have been reported using alternative large databases to address identical patient cohorts.^{17,18}

The percentage of TKA who have a history of solid organ transplant has grown at a low but steady rate between 1998 and 2011. The adjusted data show that these patients have nearly a half day longer LOS, just under \$1,000 higher cost of admission, and a 43% higher risk of complication (e.g., acute renal failure, urinary tract infections, infection of the implant, and the need for blood transfusion). While these numbers are statistically significant, they are relatively modest increases in terms of clinical significance, and support that this is a safe and useful procedure in patients with a history of solid organ transplant. This study is useful in helping to set the guidelines for expected increases in cost and resources, particularly when considering bundled payments and reimbursement strategies for specific at-risk patient populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Figure 1.
Flow diagram describing the methodology for cohort identification.

Figure 2.

Prevalence of comorbidities for total knee arthroplasty patients with (red bars) and without (blue bars) a history of solid organ transplant. * denotes a p-value < 0.05.

Figure 3.

Unadjusted trends of (A) mean length of stay (in days) and (B) mean costs per admission (in USD) for patients with (red) and without (blue) a history of solid organ transplant. Standard error bars are shown. Note that the standard error bars are too small to visualize for non-transplant patients due to large number of patients.

Figure 4.

Love plot illustrating absolute standardized differences for all patient and hospital characteristics before and after propensity score matching between subjects with and without a history of solid organ transplant. Note: value for the pre-match linear propensity score (112.4%) falls outside the scale of the graph.

Table 1

Annual Frequency of Primary TKA Status Post Solid Organ Transplant vs. Non-Transplant (1998-2011)

	Solid Organ Transplant		Non-Transplant	
Year	Frequency	Weighted Frequency ^a	Frequency	Weighted Frequency ^a
1998	28	152	43,699	220,810
1999	36	181	48,175	236,156
2000	70	342	51,902	253,183
2001	61	313	57,981	290,078
2002	69	326	67,476	321,621
2003	60	292	72,284	348,082
2004	89	431	81,684	397,148
2005	88	436	92,278	451,010
2006	99	479	94,412	457,186
2007	99	485	106,360	515,102
2008	151	728	117,025	573,044
2009	120	605	115,485	583,171
2010	142	706	123,168	609,020
2011	133	628	126,365	608,706
Overall (all years)	1,245	6,104	1,198,294	5,864,317

^aWeighted frequencies provide national estimates derived from the Nationwide Inpatient Sample.

Table 2

Demographics and Hospital Characteristics of Primary TKA Status Post Solid Organ Transplant vs. Non-Transplant (1998-2011)

	Solid Organ Transplant		Non-Transplant		
	N = 6,104		N = 5,864,317		
Variable	Frequency ^a	% of Transplant	Frequency ^a	% of Non-Transplant	P Value
Age (mean, SD), years	60.8, 10.5	-	66.8, 10.4	-	<0.0001
Age Group, years					<0.0001
18-40	245	4.0%	33,367	0.6%	
41-50	718	11.8%	344,833	5.9%	
51-60	1,786	29.3%	1,244,770	21.2%	
61-70	2,281	37.4%	1,951,787	33.3%	
71-80	1,011	16.6%	1,765,332	30.1%	
81	64	1.0%	524,229	8.9%	
Sex					<0.0001
Male	3,325	54.5%	2,133,789	36.4%	
Female	2,780	45.5%	3,720,207	63.4%	
Missing	0	0%	10,321	0.2%	
Race					<0.0001
White	3,681	60.9%	3,805,859	64.9%	
Black	510	8.4%	307,391	5.2%	
Hispanic	354	5.9%	225,200	3.8%	
Other ^b	176	2.9%	156,353	2.7%	
Unknown Race	1,383	22.9%	1,369,515	23.4%	
Insurance					0.0003
Medicare	3,847	63.0%	3,362,691	57.3%	
Medicaid	183	3.0%	148,612	2.5%	
Private/HMO	1,886	30.9%	2,123,371	36.2%	
Uninsured/Self-Pay	30	0.5%	25,330	0.4%	
Other ^b	131	2.1%	190,938	3.3%	
Missing	27	0.4%	13,376	0.2%	
Hospital Region					<0.0001
Northeast	988	16.2%	1,026,533	17.5%	
Midwest	1,822	29.8%	1,649,060	28.1%	
South	1,834	30.0%	2,070,643	35.3%	
West	1,460	23.9%	1,118,081	19.1%	
Hospital Location					<0.0001
Rural	454	7.4%	740,251	12.6%	

	Solid Organ Transplant		Non-Transplant		
	N = 6,104		N = 5,864,317		
Variable	Frequency ^a	% of Transplant	Frequency ^a	% of Non-Transplant	P Value
Urban	5,622	92.1%	5,104,763	87.1%	
Missing	29	0.5%	19,302	0.3%	
Hospital Bed Size					<0.0001
Small	625	10.2%	896289	15.3%	
Medium	1,390	22.8%	1,472,364	25.1%	
Large	4,060	66.5%	3,476,362	59.3%	
Missing	29	0.5%	19,302	0.3%	
Hospital Teaching					<0.0001
Non-Teaching	2,463	40.4%	3,383,924	57.7%	
Teaching	3,613	59.2%	2,461,091	42.0%	
Missing	29	0.5%	19,302	0.3%	

HMO, healthcare maintenance organization

^a Presented frequency values are weighted to provide national estimates, 1998-2011.

^b Other Race = Asian/Pacific Islander, Native American, and Other; Other Insurance = No Charge, Other

Table 3

Procedure-Related Complications Following Primary TKA Status Post Solid Organ Transplant vs. Non-Transplant (1998-2011)

		Solid Organ Transplant		Non-Transplant		
		(N = 6,104)		(N = 5,864,317)		
Complication	ICD-9 Code (DX2-DX25)	Weighted Frequency	% of Transplant	Weighted Frequency	% of Non-Transplant	P Value *
<i>Mechanical complication of internal orthopaedic device, implant, graft (ALL)</i>						
Dislocation of prosthetic joint or peri-prosthetic fracture around prosthetic joint	99642, 99644	0	0%	380	0.01%	-----
<i>Procedure related complications</i>						
Central nervous system	9970%	0	0%	6,223	0.11%	-----
Cardiac	9971	65	1.06%	50,402	0.86%	0.4293
Peripheral vascular (i.e., phlebitis or thrombophlebitis during or resulting from a procedure)	9972	15	0.25%	12,284	0.21%	0.7760
Respiratory	9973%	58	0.95%	43,601	0.74%	0.3866
Gastrointestinal	9974%	41	0.67%	34,619	0.59%	0.7006
Gastrourinary	9975	64	1.05%	39,918	0.68%	0.1127
Postoperative shock	9980	0	0%	1,257	0.02%	-----
Bleeding (Hematoma/seroma, hemarthrosis)	9981%, 71915	65	1.06%	47,427	0.81%	0.3283
Infection (i.e., postoperative infection or implant infection)	9985%, 99666-7, 99669	39	0.64%	12,654	0.22%	0.0015
<i>Wound related complications</i>						
Wound complications (i.e., wound dehiscence, nonhealing surgical wound, or cellulitis)	9983%, 99883, 6826, 6869	23	0.38%	19,038	0.32%	0.7306
<i>Other adverse events</i>						
Arrhythmia	427	479	7.85%	494,824	8.44%	0.4789
Urinary tract infection	5990, 5950	184	3.01%	135,890	2.32%	0.1037
Pulmonary embolism	4151%	30	0.49%	25,474	0.43%	0.7349
Deep venous thrombosis	4511%, 4512, 45181, 4519, 4532, 4534%, 4538, 4539	55	0.90%	36,181	0.62%	0.2130
Pulmonary insufficiency after trauma and surgery/adult respiratory distress syndrome	5185	15	0.25%	15,553	0.27%	0.8583
Transfusion of blood products	PR2-15: 9903, 9904, 9905, 9907	1,080	17.69%	682,979	11.65%	< 0.0001
<i>Organ-specific complications</i>						
Other organ-specific complications	DX ANY: 9976%, 9977%, 9979%	10*	0.18%*	6634	0.11%	0.7307

* Cells with frequency <11 are suppressed due to requirements in the HCUP data use agreement.

Table 4

Effect of Transplant History on Outcomes among Total Hip Arthroplasty Patients after Propensity Score Matching.

Variable		Difference in means	95% CI	P Value
LOS, days		0.4389	0.2912–0.5866	<0.0001
Cost per admission, \$		962.3	413.6 – 1511.0	0.0006
		Odds Ratio		
Any complication	ICD-9 codes	1.430	1.187 – 1.723	0.0002
Dislocation of prosthetic joint or peri-prosthetic fracture around prosthetic joint	99642, 99644	< 25 weighted frequency before and after matching	n/a	n/a
Cardiac	9971	0.916	0.403 – 2.084	0.8341
Respiratory	9973%	1.378	0.553 – 3.439	0.4914
Gastrointestinal	9974%	0.799	0.314 – 2.031	0.6368
Gastourinary	9975	0.748	0.314 – 1.782	0.5123
Bleeding (hemorrhage, hematoma, seroma, hemathrosis)	9981%, 71915	1.202	0.517 – 2.793	0.6688
Infection (postoperative infection, implant infection)	9985%, 99666-7, 99669	< 25 weighted frequency after matching	n/a	n/a
Wound complications (i.e., wound dehiscence, nonhealing surgical wound, or cellulitis)	9983%, 99883, 6826, 6869	< 25 weighted frequency before and after matching	n/a	n/a
Arrhythmia	427	0.989	0.738 –	0.9404
			1.326	
Urinary tract infection	5990	1.467	0.847 – 2.540	0.1711
Pulmonary embolism	4151%	0.856	0.287 – 2.556	0.7811
Deep venous thrombosis	4511%, 4512, 45181, 4519, 4532, 4534%, 4538, 4539	1.672	0.606 – 4.616	0.3209
Allogenic transfusion	PR2-15: 9903, 9904, 9905, 9907	1.688	1.335 – 2.136	<0.0001

Note:

Analysis was conducted on the propensity score matched sample. Cost and Length of Stay outcomes were calculated as the difference in means between transplant patients and non-transplant patients. Complications outcomes were measured as odds ratios comparing transplant vs. non-transplant patients, and were obtained from logistic regression.

CI, confidence interval; LOS, length of stay; MI, myocardial infarction; ARF, acute renal failure; UTI, urinary tract infection