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Hip and knee arthroplasty utilization and outcomes in the United States and Canada: an analysis of New York and Ontario administrative data

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Abstract

Objective—Total knee and total hip arthroplasty (TKA and THA) are common and effective surgical procedures. We compared utilization and short-term outcomes of primary TKA and THA in adjacent regions of Canada and the United States.

Methods—Retrospective cohort study of patients who underwent primary TKA or THA using administrative data from New York (NY) and Ontario in 2012–2013. We compared TKA and THA patient demographics, per-capita utilization, and short-term outcomes between jurisdictions.

Results—A higher percentage of NY hospitals performed TKA compared to Ontario (75.7% vs 42.1%; P<.001) and mean hospital volume was lower in NY (179 vs 327; P<.001). After direct standardization, utilization was significantly lower in NY compared to Ontario for both TKA (16.2 TKAs per 10,000 population per-year in NY vs 21.4 in Ontario; P<.001) and THA (10.5 in NY vs 11.5 in Ontario; P<.001). For TKA Ontario hospitals' LOS was significantly longer compared to NY (3.7 vs 3.4 days; P<.001). A smaller percentage of NY patients were discharged directly home (46.2% vs 90.9%; P<.001), but 30-day and 90-day readmission rates were higher in NY compared to Ontario (30-day: 4.6% vs 3.9%; P<.001)(90-day: 8.4% vs 6.7%; P<.001). Results were similar for THA.

Conclusion—Ontario has higher TJA utilization than NY, but a smaller percentage of hospitals performing these procedures. Patients are more likely to be discharged home and less likely to be readmitted in Ontario. Our results suggest areas where each jurisdiction could improve.

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Introduction

Primary total knee arthroplasty (TKA) and total hip arthroplasty (THA) are safe and effective treatments for patients with advanced arthritis.(1, 2) With an ageing population, demand for total joint arthroplasty (TJA [which includes both TKA and THA]) is increasing.(3, 4)

Unlike emergency procedures such as hip fracture repair or percutaneous coronary intervention for ST-elevation myocardial infarction (STEMI), primary TKA and THA are prototypical “preference sensitive” procedures. Patients and providers have considerable discretion over when and whether to proceed with surgery.(5) Payers, both public and private, have considerable interest in restraining TJA utilization given that each surgery costs between $10,000–$20,000(6, 7). Most publicly funded healthcare systems (e.g., Canada, England) use some sort of rationing to limit surgical volumes,(8), often resulting in wait times of 2–12months.(9) At the same time, government payers face relentless political pressure from patients and physicians to minimize wait times.(10) By comparison, the United States (US) uses a relatively laissez faire approach to controlling volumes for most procedures including TJA. There is a general belief that utilization rates of most procedures including TJA are far higher in the US than in other Organization for Economic Cooperation and Development (OECD) countries,(11, 12) but empirical data are extremely limited.(13, 14).(15)

We used data from New York State (NY) and Ontario to compare primary TKA and THA utilization, hospital volumes, and short-term outcomes (length-of-stay [LOS], readmission rates, and discharge disposition). We hypothesized that: 1) TJA utilization would be higher in New York compared to Ontario; 2) hospital volumes would be lower in New York; 3) a greater percentage of Ontario residents would be discharged home after surgery.

Methods

New York State Inpatient Data (SID)

We used New York State Inpatient Database (SID) obtained as part of the Agency for Healthcare Research and Quality (AHRQ) Healthcare Cost and Utilization Project (HCUP).(16) The SID has been used extensively in prior research.(17) Briefly, the SID contains administrative data for all patients admitted to acute care hospitals excluding small numbers of hospitals operated by the Veterans Administration Health System and certain specialty hospitals such as psychiatric hospitals. Data elements provided by AHRQ for each admission include patient demographics (age in years, sex), primary and secondary diagnosis and procedures (coded using International Classification for Diseases 9th Clinical Modification [ICD9-CM] codes), discharge disposition (e.g., died-in-hospital, home, post-acute-care), a unique patient identifier (used to track patient readmissions over time), and a unique hospital identifier. Comorbid conditions are captured using algorithms developed by Elixhauser et al.(18)

Ontario Data

We used Ontario Discharge Abstract Data (DAD) obtained through the Institute for Clinical and Evaluative Sciences (ICES). These records provide information on all hospitalizations paid for by the Ontario provincial health insurance plan, which pays for virtually all hospital care provided within the province and provides insurance to all legal residents of Ontario (virtually 100% of the population).(19, 20) Similar to the SID files, Ontario's discharge abstract data (DAD) provide information regarding patient demographics, primary and secondary diagnosis coded using ICD-10 codes for each hospitalization, discharge disposition, and patient and hospital identifiers. Comorbid conditions were identified using the Quan ICD-10 adaptation of the Elixhauser comorbidity coding scheme.(21)

Cohort generation

We identified adults age 18 years and greater who underwent primary TKA and THA between January 1, 2012 and September 30, 2013 using ICD9-CM codes 81.54 and 81.51 for the SID and Canadian Classification of Intervention codes VG53 and VA53 in Ontario; data from September 30th– December 31, 2013 was used for ascertainment of 90-day readmission only.(22) We excluded patients with codes suggestive of trauma, hip fracture, patients whose procedures were performed on an emergent basis (as primary TKA and THA are typically not urgent), patients with a prior TKA or THA within 90-days of the index procedure (because of concern that the 2nd admission could represent a readmission), and patients who underwent 2-or-more TKA or THA procedures during the same hospitalization. Inclusion and exclusion criteria were applied using similar methods to the SID and Ontario data.

Outcomes

Our study included 4 complementary outcomes: 1) per-capita utilization of TKA and THA; 2) hospital length-of-stay (LOS); 3) discharge disposition (home versus other); and 4) all-cause hospital readmission occurring within 30-days and 90-days of discharge. After identifying all primary TKA and THA procedures performed in New York and Ontario, we calculated annual utilization rates (per 10,000 population). Estimates of the New York population were obtained from US Census Data (available at https://www.health.ny.gov/statistics/vital_statistics/2010/table01.htm); estimates of the Ontario population were obtained analogous Canadian census data. We linked the New York data to the American Hospital Association annual survey to ascertain information regarding hospital teaching status and bed size. We linked the Ontario DAD to the Ontario Health Insurance Plan Registered Persons Database for mortality information, and to information from the Ontario Ministry of Health and Long-Term Care.

Analyses

Analyses were conducted separately for the TKA and THA cohorts using similar methods and approaches. First, we compared patient demographics and key comorbid conditions captured during the inpatient hospitalization for patients who underwent TKA in New York and Ontario. We compared continuous measures using the t-test and categorical measures using the chi-square statistic. Second, we compared the percentage of hospitals in New York and Ontario performing TKA, the mean and median annual surgical volumes at these hospitals, and the percentage of hospitals performing TKA that were categorized as major teaching hospitals using similar bivariate methods.(23) Similar analyses were performed for the THA cohorts.

Third, we calculated annualized primary TKA utilization rates (procedures per-10,000 per-year) for New York and Ontario. The numerator for these calculations was the annualized number of TKA procedures performed between January 1, 2012 and September 30, 2013 while the denominator was the population of adults age ≥ 18 years. We calculated utilization for the entire adult population (age >18 years), age specific population strata (e.g., age <50, 50–59, etc), and by patient sex (men and women) using analogous numerators and denominators. Similar analyses were performed for the THA cohort. We calculated standardized TKA and THA utilization rates for New York using direct standardization with the Ontario population used as the reference; this allows us to compare utilization in New York and Ontario assuming similar population demographics in terms of age and sex.(24) We compared utilization for TKA and THA in New York and Ontario using Poisson regression.

Fourth, we compared unadjusted outcomes for TKA and THA in New York and Ontario. In particular we compared mean hospital LOS, discharge disposition, and hospital readmission within 30-days and 90-days of surgery. Fifth, we examined adjusted outcomes for each study endpoint using generalized linear models. We used 3 statistical models for each endpoint: Model 1 adjusted only for patient demographics; Model 2 adjusted for demographics plus hospital procedure volume. Model 3 adjusted for all Model 2 factors plus comorbid conditions. Comorbid conditions were included in our models based upon clinical plausibility and having a reasonable prevalence in both our New York and Ontario populations; of note, because in-hospital mortality was extremely rare, statistical concerns allowed us to include only 2 comorbid conditions mortality model 3. This analysis was approved by the Research Ethics Board at ICES. All analyses were performed using either SAS (Cary, North Carolina) or R statistical software packages.

Results

We identified 40,418 primary TKAs performed in Ontario and 40,831 TKAs performed in New York State between January 1, 2012 and September 30, 2013 (Table 1). For THA our cohorts consisted of 21,513 in Ontario and 26,605 in New York (Table 1).

Focusing on TKA, a smaller percentage of procedures in Ontario were performed on patients age <50 years when compared to New York (2.6% vs 5.0%; P<.001)(Table 1). A smaller percentage of TKAs in Ontario were performed on women when compared to New York (62.7% vs 65.4%; P=<.001). Prevalence of all comorbid conditions was significantly lower in Ontario when compared to New York. Findings for THA followed a similar pattern (Table 1).

Continuing to focus on TKA (Table 2), a significantly smaller percentage of Ontario hospitals performed TKA when compared to New York hospitals (42.1% vs 75.7%; P<.001).

Alternatively, mean TKA hospital annual volume in Ontario was significantly higher than New York volume (327 vs 179; P<.001). Results focusing on THA were similar (Table 2) with a lower percentage of Ontario hospitals performing the procedure with higher mean hospital THA volume.

Using direct standardization, TKA utilization per 10,000 adults in Ontario was significantly higher (21.4) as compared to New York (16.1)(P<.001)(Table 3). In stratified analyses utilization in Ontario was significantly higher for all age strata when compared to New York with the exception of patients < 50-years of age (Table 3). Utilization was significantly higher in Ontario for both women and men. Results focusing on THA (Table 3) again showed higher utilization in Ontario when compared to New York both in aggregate and for most age strata.

In analyses focusing on unadjusted outcomes (Table 4) hospital LOS for TKA in Ontario was significantly longer than for New York (3.7 vs 3.4 days; P<.001) while in-hospital TKA mortality was statistically significantly higher in Ontario, though the difference was clinically small (.07% vs. .03%; P= .035). A significantly higher percentage of Ontario TKA patients were discharged home after surgery as compared to New York (90.9% vs 46.2%; P<.001). In addition, a lower percentage of Ontario TKA patients were transferred to another acute-care hospital compared to New York patients (0.7% vs 2.8%; P<.001). Hospital readmission within 30-days of TKA was lower for Ontario as compared to New York (3.9% vs 4.6%; P<.001); similarly, readmission within 90-days was lower in Ontario as compared to New York (6.7% vs 8.4%; P<.001). Results focusing on THA revealed similar Ontario-New York differences (Table 4).

In adjusted analyses focusing on TKA (Table 5), mortality was similar in Ontario and New York in all models. Hospital LOS for TKA was significantly longer in Ontario in all statistical models while both 30-day and 90-day readmission rates were significantly lower in Ontario. Adjusted analyses focusing on THA demonstrated similar results (Table 6).

Interpretation

In an analysis of population-based administrative data we found that utilization of both TKA and THA were higher in Ontario (Canada) as compared to New York (US). We also found that a smaller percentage of Ontario hospitals performed TJA and Ontario hospitals had higher surgical volumes compared to New York counterparts. Finally, Ontario hospitals appeared to have shorter hospital LOS, lower rates of hospital readmissions, and a significantly higher percentage of Ontario residents were discharged home after surgery.

Several of our results warrant elaboration. It is important to consider our TKA and THA utilization data in the context of prior studies of joint arthroplasty utilization. In prior analysis of US Medicare data (adults age ≥ 65 years) we found primary TKA and THA utilization of approximately 60 procedures and 25 procedures per-10,000 population per-year in 2008–2010.(25–27) Looking at the findings of the current study, we found roughly similar utilization rates in our older populations.

There are very few studies that have directly compared TKA and THA utilization and outcomes in different countries. Pabinger and colleagues used pooled data obtained from the Organization for Economic Cooperation and Development to examine TJA utilization in approximately 20 countries. They found TKA utilization ranging between 2 (Poland) and 23 (US) per 10,000 population (13) and THA between 8 (Poland) and 29 (Germany) per 10,000 in 2011. We are aware of only a one study that directly compared TKA and THA utilization in the US and Canada. In this study Ravi et al used 2001–2007 data from the US Nationwide Inpatient Sample and the province of Ontario; the team found that in 2001 utilization of TKA and THA were approximately 30% and 10% higher respectively in the US when compared to Ontario, but that differences had declined by 2007.(15)

Historically most single-payer healthcare systems have done relatively well with cost-control, but have fared poorly with access. The phenomenon of wait lists for elective surgical procedures including TKA and THA in Ontario has been well described as well as the negative impact of wait times on patients' physical function.(28, 29) In the early part of the 21st Century the Canadian government (including Ontario) faced considerable public pressure to improve access and reduce wait times and improved access to TJA.(30, 31) The government responded with an array of new initiatives and policies. We suspect that these efforts explain our finding that TJA utilization in Ontario has now surpassed utilization in New York.

While differences in healthcare system structures and financing might explain the differences in TJA utilization we have observed, there are other potential explanations. It is possible differences in the prevalence of advanced osteoarthritis or obesity could underlie the differences in TJA utilization that we have observed, but we are unaware of any convincing data supporting this hypothesis.(32–34) Another possibility for higher utilization in Ontario would be if there were a lower threshold for surgery as compared to medical management in Ontario as compared to New York. While appropriateness criteria for TJA have been developed,(35–37) widespread implementation has been limited by the need for detailed clinical, radiographic, and patient-reported symptom scores. Our reliance upon administrative data precludes us from investigating appropriateness in this study, but this is certainly an area for further investigation.

We observed that a substantially smaller percentage of Ontario hospitals offered TJA and those that offered TJA had significantly higher volumes than New York hospitals; this likely reflects differences in regulatory environment. Ontario- like many single payer systems with substantial government involvement- relies upon centralized planning to determine which hospitals should offer which services.(38, 39) In the US, hospitals are encouraged to be entrepreneurial with the idea that competition breeds lower price and higher quality; hospitals are typically able to offer most clinical services with minimal regulatory barriers. Moreover, in the US TJA is typically thought to be profitable for hospitals.(7) Thus, it is not surprising that the percentage of hospitals performing TJA in New York is far higher, but volumes substantially lower when compared to Ontario.

It is important to speak to differences in outcomes we observed. Patients in Ontario were much more likely to be discharged home and much less likely to be discharged to post-acute care (e.g., inpatient rehabilitation) when compared to patients in New York. Post-acute care is expensive and supply in Ontario is extremely limited making discharge home the preferred option.(40) In contrast, post-acute care in the US is typically available and covered by insurance making it easy for hospitals to discharge patients to rehabilitation. It is noteworthy that even with approximately 90% of Ontario patients discharged home after TJA, hospital readmission rates were actually lower than in New York. The combination of lower utilization of post-acute care in Ontario combined with lower readmission rates suggests that there are still significant efficiencies to be gained in the US.(41, 42)

A number of other findings warrant brief mention. We would be remiss if we did not speak to the differences in comorbidity that we observed. One possible explanation would be that TKA and THA recipients in New York truly have prevalence rates of heart failure, hypertension, and diabetes that are markedly higher than in Ontario; this seems implausible. Rather, we suspect that the well-recognized pressure to “up-code” for purposes of reimbursement and risk-adjustment are the major driver of the differences we have observed. (43, 44) If differences in comorbidity reflect cross-border differences in coding practices rather than true differences in prevalence of comorbid conditions adjust for such comorbidities could introduce major bias into risk-adjustment models.

It is important to point out limitations in our study. First, our analysis was limited to patients in Ontario and New York State; generalizing our findings to entire countries of Canada and the US should be done with caution, particularly given the marked differences in healthcare delivery across Canada’s different provinces. Second, our study relied upon hospital administrative data and lacked reliable information on comorbidities; we also were unable to assess patient reported outcomes and long-term follow-up. Third, we were unable to exclude unicomparmental procedures from our TKA cohort because of limitations in the granularity of ICD9 coding and unicomparmental procedures represent approximately 10% of knee arthroplasty procedures.(45, 46) We did include unicompartmental procedures in both our New York and Ontario cohorts to avoid biasing our results. Fourth, we are unable to comment on the indications for each procedure or clinical appropriateness.(36, 47, 48) Thus, while utilization in Ontario was greater than that in New York, we are unable to say whether higher TJA utilization represents underuse in New York or overuse in Ontario.

In sum, we found higher utilization of TJA in Ontario than New York, but evidence of greater efficiency (e.g., higher hospital volume, shorter hospital LOS, and lower readmission rates) in Ontario. Taken together our results hint at opportunities for further improvement in each locale.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1

Characteristics of patients who underwent primary TKA or primary THA in Ontario or New York State in 2012–13

	TKA			THA		
	Ontario (N=40,118)	**NY (N=40,831)**	**P-value**	**Ontario (N=21,513)**	**NY (N=26,605)**	**P-value**
Patient demographics						
Age, <50, number (%)	1,058 (2.6)	2,032 (5.0)	<.001	1,485 (6.9%)	2,376 (8.9)	<.001
Age, 50–59, number (%)	7,348 (18.3)	8,493 (20.8)		4,094 (19.0%)	6,071 (22.8)	
Age, 60–69, number (%)	14,759 (36.8)	14,413 (35.3)		6,747 (31.4%)	8,493 (31.5)	
Age, 70–79, number (%)	12,418 (31.0)	11,723 (28.7)		6,135 (28.5%)	6,491 (24.4)	
Age, 80–89, number (%)	4,402 (11.0)	4,057 (9.9)		2,868 (13.3%)	3,087 (11.6)	
Age, ≥90, number (%)	133 (0.3)	113 (0.3)		184 (0.9%)	192 (0.7)	
Female, number (%)	25,154 (62.7)	26,684 (65.4)	<.001	11,966 (55.6%)	14,493(56.6)	.004
Comorbid conditions						
Congestive heart failure	320 (0.8%)	1,416 (3.5)	<.001	155 (0.7%)	1,114 (4.2)	<.001
Coronary artery disease	568 (1.4%)	2,128 (5.2)	<.001	322 (1.5%)	1,647 (6.2)	<.001
Hypertension with complications	31 (0.1%)	2,112 (5.2)	<.001	14 (0.1%)	1,432 (5.4)	<.001
Diabetes	6,966 (17.4%)	8,790 (21.5)	<.001	2,538 (11.8%)	4,106 (15.4)	<.001
COPD	1,738 (4.3%)	6,611 (16.2)	<.001	889 (4.1%)	3,939 (14.8)	<.001
Renal Failure	279 (0.7%)	2,251 (5.5)	<.001	181 (0.8%)	1,572 (5.9)	<.001

Table 2

Hospital characteristics

	TKA			THA		
	Ontario (N=164)	**NY (N=202)**	**P-value**	**Ontario (N=164)**	**NY (N=202)**	**P-value**
Hospitals performing procedure, number (%)	69 (42.1)	153 (75.7)	<.001	68 (41.5)	155 (76.7)	<.001
Annual procedural volume, mean (SD)	327 (222)	179 (324)	<.001	181 (146)	120 (299)	.011
Annual procedural volume, median (Inter-quartile range)	291 (189–428)	93 (30–208)	N/A	153 (82–223)	50 (16–127)	N/A
Hospital volume (for those performing ≥ 1 procedure), number (%)						
<25	1 (1.5%)	34 (22.2%)	<.001	4 (5.9%)	30 (19.4%)	<.001
25–49	2 (2.9%)	14 (9.2%)		4 (5.9%)	14 (9.0%)	
50–99	8 (11.6%)	14 (9.2%)		15 (22.1%)	19 (12.3%)	
100–199	9 (13.0%)	17 (11.1%)		23 (33.8%)	12 (7.7%)	
200–299	16 (23.2%)	19 (12.4%)		12 (17.7%)	27 (17.4%)	
300–399	12 (17.4%)	30 (19.6%)		4 (5.9%)	13 (8.4%)	
≥ 400	21 (30.4%)	25 (16.3%)		6 (8.8%)	40 (25.8%)	
Bed number, mean (SD)	214 (143)	92 (52)	<.001	216 (143)	91 (52)	<.001
Major teaching, number (%)	13 (18.8)	25 (16.7)	.791	13 (19.1)	25 (16.4)	.724

Table 3

Per-capita TKA and THA numbers and utilization (procedures per-10,000 per-year)

	Ontario			New York			TKA Utilization[1]			THA Utilization[2]		
	TKA number	THA number	Population	TKA number	THA number	Population	Ontario	NY	P-value	Ontario	NY	P-value
Total	40,118	21513	10,694,170	40831	26605	15053173	21.44	16.14	<.001	11.5	10.51	<.001
Age, <50, number (%)	1,058 (2.6%)	1485 (6.9%)	5,987,033 (56.0%)	2032 (5.0%)	2376 (8.9%)	8711634 (57.9%)	1.01	1.33	<.001	1.42	1.60	.5
Age, 50–59, number (%)	7,348 (18.3%)	4094 (19.0%)	1,958,582 (18.3%)	8493 (20.8%)	6071 (22.8%)	2657336 (17.7%)	21.44	18.26	<.001	11.94	13.06	.864
Age, 60–69, number (%)	14,759 (36.8%)	6747 (31.4%)	1,392,999 (13.0%)	14413 (35.3%)	8378 (31.5%)	1839471 (12.2%)	60.54	44.77	<.001	27.68	26.03	<.001
Age, 70–79, number (%)	12,418 (31.0%)	6135 (28.5%)	818,017 (7.6%)	11723 (28.7%)	6491 (24.4%)	1062198 (7.1%)	86.75	63.07	<.001	42.86	34.92	<.001
Age, 80+, number (%)	4535 (11.3%)	3052 (14.2%)	537539 (5.0%)	4170 (10.2%)	3289 (12.4%)	782534 (5.2%)	48.21	30.45	<.001	32.44	24.02	<.001
Men, number (%)	14964 (37.3%)	9547 (44.4%)	5193017 (48.6%)	14147 (34.6%)	11612 (43.6%)	7165866 (47.6%)	16.47	11.28	<.001	10.51	9.26	<.001
Women, number (%)	25154 (62.7%)	11966 (55.6%)	5501153 (51.4%)	26684 (65.4%)	14993 (56.4%)	7887307 (52.4%)	26.13	19.33	<.001	12.43	10.86	<.001

[1] Total Utilization for NY are directly standardized to match the age and sex of the Ontario population.

[2] Total Utilization for NY are directly standardized to match the age and sex of the Ontario population.

Table 4

Unadjusted outcomes

	TKA			THA		
	Ontario (N=40,118)	**NY (N=40,831)**	**P-value**	**Ontario (N=21,513)**	**NY (N=26,605)**	**P-value**
Length-of-stay, mean (SD)	3.72 (2.1)	3.43 (1.8)	<.001	3.91 (2.5)	3.46 (2.4)	<.001
Discharge disposition						
Died in-hospital, number (%)	27 (.07)	13 (.03)	.035	18 (0.1)	16 (.06)	.428
Home, number (%) number (%)	36,479 (90.9)	18,865 (46.2)	<.001	19054 (88.6)	14,078 (52.9)	<.001
Transfer to another acute-care hospital, number (%)	280 (.7)	1,129 (2.8)	<.001	272 (1.3)	569 (2.1)	<.001
Post-acute-care, (%)	3,312 (8.3)	20,810 (51.0)	<.001	2161 (10.1)	11,934 (44.9)	<.001
Other	20 (0.05)	14 (.03)	.363	8 (0.04)	8 (.03)	.862
Readmission						
30-day hospital readmission, number (%)	1,569 (3.9)	1,862 (4.6)	<.001	1017 (4.7)	1,134 (4.3)	.015
90-day hospital readmission, number (%)	2,666 (6.7)	3,403 (8.4)	<.001	1603 (7.5)	2,197 (8.3)	.001

Table 5

Adjusted outcomes for TKA

	Model 1[‡]		Model 2[§]		Model 3[**]	
	NY	**ON**	**NY**	**ON**	**NY**	**ON**
In-hospital mortality, % (95% confidence intervals)	0.019 (0.008,0.046)	0.035 (0.018,0.066)	0.028 (0.012,0.067)	0.033 (0.016,0.065)	0.025 (0.010,0.062)	0.027 (0.013,0.055)
Hospital LOS, days, (95% confidence intervals)	3.454 (3.432,3.476)	3.856 (3.827,3.885)	3.474 (3.451,3.498)	3.815 (3.783,3.847)	3.463 (3.434,3.491)	3.690 (3.656,3.723)
30-day readmission, % (95% confidence intervals)	4.136 (3.903,4.383)	3.353 (3.136,3.584)	4.498 (4.23,4.781)	3.498 (3.256,3.757)	4.411 (4.097,4.749)	3.210 (2.971,3.468)
90-day readmission, % (95% confidence intervals)	8.161 (7.73,8.613)	5.989 (5.702,6.290)	8.359 (8.000,8.732)	6.100 (5.783,6.433)	8.950 (8.380,9.556)	5.727 (5.408,6.065)

[‡] Model 1: adjusted for patient age and sex

[§] Model 2: adjusted for Model 1 plus hospital TKA volume

[**] Model 3: adjusted for Model 2 factors plus comorbid conditions

Table 6

Adjusted outcomes for THA

	Model 1††		Model 2‡‡		Model 3§§	
	NY	**ON**	**NY**	**ON**	**NY**	**ON**
In-hospital mortality, % (95% confidence intervals)	0.019 (0.007,0.055)	0.041 (0.018,0.097)	0.025 (0.008,0.074)	0.045 (0.019,0.110)	0.023 (0.007,0.070)	0.040 (0.017,0.097)
Hospital LOS, days (95% confidence intervals)	3.486 (3.447,3.525)	4.161 (4.100,4.221)	3.579 (3.538,3.621)	4.139 (4.072,4.206)	3.565 (3.516,3.613)	4.013 (3.944,4.081)
30-day readmission, % (95% confidence intervals)	4.065 (3.757,4.397)	4.133 (3.784,4.511)	4.472 (4.119,4.854)	4.243 (3.857,4.667)	4.549 (4.137,5.000)	4.006 (3.625,4.424)
90-day readmission, % (95% confidence intervals)	8.161 (7.73,8.613)	6.932 (6.486,7.407)	8.866 (8.377,9.381)	7.064 (6.567,7.595)	8.948 (8.377,9.553)	6.688 (6.196,7.215)

††Model 1: adjusted for patient age and sex

‡‡Model 2: adjusted for Model 1 plus hospital TKA volume

§§Model 3: adjusted for Model 2 factors plus comorbid conditions