The Journal of Arthroplasty xxx (2017) 1–5

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

The Seasonal Variability of Surgical Site Infections in Knee and Hip Arthroplasty

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ARTICLE INFO

Article history:
Received 1 October 2017
Received in revised form
20 October 2017
Accepted 24 October 2017
Available online xxx

Keywords:
knee arthroplasty
hip arthroplasty
surgical site infection
seasonality
weather
temperature

ABSTRACT

Background: Surgical site infections (SSIs) after total knee (TKA) and total hip (THA) arthroplasty are devastating to patients and costly to healthcare systems. The purpose of this study is to investigate the seasonality of TKA and THA SSIs at a national level.
Methods: All data were extracted from the National Readmission Database for 2013 and 2014. Patients were included if they had undergone TKA or THA. We modeled the odds of having a primary diagnosis of SSI as a function of discharge date by month, payer status, hospital size, and various patient co-morbidities. SSI status was defined as patients who were readmitted to the hospital with a primary diagnosis of SSI within 30 days of their arthroplasty procedure.
Results: There were 760,283 procedures (TKA 424,104, THA 336,179) in our sample. Our models indicate that SSI risk was highest for patients discharged from their surgery in June and lowest for December discharges. For TKA, the odds of a 30-day readmission for SSI were 30.5% higher at the peak compared to the nadir time (95% confidence interval [CI] 20-42). For THA, the seasonal increase in SSI was 19% (95% CI 9-30). Compared to Medicare, patients with Medicaid as the primary payer had a 49% higher odds of 30-day SSI after TKA (95% CI 32-68).
Conclusion: SSIs following TKA and THA are seasonal peaking in summer months. Payer status was also a significant risk factor for SSIs. Future studies should investigate potential factors that could relate to the associations demonstrated in this study.

Surgical site infections (SSIs) are a major cause of morbidity and mortality [1–4]. In addition, SSIs generate longer lengths of stay [3,5], hospital readmissions [3,6,7], and substantially increase the cost of healthcare delivery [1,2,5,7]. Although SSI rates are relatively lower for elective orthopedic procedures [8–11] than emergent procedures, they are important to prevent given the large number of total hip arthroplasty (THA) and total knee arthroplasty (TKA) performed each year [12,13]. Additionally, the number of joint arthroplasties is expected to continue to increase along with the costs for treating arthroplasty-associated SSIs [14].

Several patient-level risk factors for SSIs have been described including diabetes [15,16], obesity [17], increasing age [16,18], poor nutrition [19], smoking [16,20], and colonization with *Staphylococcus aureus* [21]. Because some of these risk factors are modifiable prior to surgery, elective orthopedic procedures present a unique opportunity for designing interventions to prevent SSIs. However, the design of such interventions is dependent on an understanding of SSI risk factors. We recently reported that SSIs were not only seasonal but also dependent on local weather patterns. Specifically,

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.arth.2017.10.043.

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https://doi.org/10.1016/j.arth.2017.10.043

Table 1
Summary of Important Variables by Procedure Type (Sample Sizes Are Weighted).

	TKA, n (%)	THA, n (%)	Total, n (%)
Age group			
<18	1007 (0.1%)	602 (0.1%)	1608 (0.1%)
(18, 30)	1789 (0.2%)	3557 (0.5%)	5346 (0.3%)
(30, 40)	5331 (0.5%)	11,439 (1.5%)	16,770 (1%)
(40, 50)	42,956 (4.4%)	47,170 (6.1%)	90,126 (5.1%)
(50, 60)	211,002 (21.5%)	160,148 (20.7%)	371,150 (21.1%)
(60, 70)	368,878 (37.5%)	228,983 (29.6%)	597,861 (34%)
(70, 80)	271,806 (27.7%)	184,599 (23.8%)	456,405 (26%)
80+	80,065 (8.1%)	138,221 (17.8%)	218,286 (12.4%)
Primary payer			
Medicare	543,346 (55.3%)	441,704 (57%)	985,050 (56%)
Medicaid	32,947 (3.4%)	27,216 (3.5%)	60,163 (3.4%)
Private insurance	362,355 (36.9%)	277,955 (35.9%)	640,310 (36.4%)
Self-pay	4114 (0.4%)	5198 (0.7%)	9311 (0.5%)
No charge	826 (0.1%)	975 (0.1%)	1801 (0.1%)
Other	38,136 (3.9%)	20,945 (2.7%)	59,081 (3.4%)
Missing	1110 (0.1%)	726 (0.1%)	1836 (0.1%)
Hospital size			
Small	223,937 (22.8%)	168,641 (21.8%)	392,578 (22.3%)
Medium	267,909 (27.3%)	206,103 (26.6%)	474,012 (27%)
Big	490,989 (50%)	399,975 (51.6%)	890,964 (50.7%)
Hospital location			
Metropolitan non-teaching	356,884 (36.3%)	258,582 (33.4%)	615,466 (35%)
Metropolitan teaching	516,758 (52.6%)	442,220 (57.1%)	958,978 (54.6%)
Non-metropolitan	109,192 (11.1%)	73,918 (9.5%)	183,110 (10.4%)
Female indicator	602,796 (61.3%)	436,676 (56.4%)	1,039,472 (59.1%)
Hypertension flag	650,621 (66.2%)	462,779 (59.7%)	1,113,399 (63.3%)
Obesity flag	246,156 (25%)	121,734 (15.7%)	367,890 (20.9%)
Diabetes flag	188,553 (19.2%)	102,792 (13.3%)	291,345 (16.6%)
30-d SSI readmission	5217 (0.5%)	4773 (0.6%)	9991 (0.6%)
Continuous variables	Mean (SD)	Mean (SD)	Mean (SD)
Length of stay	3.004 (1.93)	3.35 (2.884)	3.157 (2.405)
Number of diagnoses	7.761 (4.322)	8.175 (4.842)	7.943 (4.564)
Number of procedures	1.106 (0.429)	1.56 (0.721)	1.306 (0.621)

SD, standard deviation.

the risk for SSIs increased during warmer months in a dose-dependent fashion [22]. However, we were unable to determine the seasonality of SSIs after specific orthopedic procedures. Other reports have demonstrated that the incidence of SSIs increased during summer months for patients undergoing spine surgery [23,24] and total joint arthroplasty [25], as well as other surgical procedures [26]. However, these results were mostly single center or regional investigations.

The primary objective of this study is to determine if the incidence of SSIs following TKA and THA is seasonal in a large, population-based cohort after adjusting for other possible risk factors.

Methods

Data Extraction

This study was deemed exempt by our institutional review board. All data were extracted from the National Readmission Database (NRD), which is a newer addition to a family of databases developed for the Healthcare Cost and Utilization Project (HCUP) by the Agency for Healthcare Research and Quality. Available for the years 2013 and 2014, the NRD offers unique patient identifiers that allow us to link patients across visits. The NRD contains data from 22 geographically dispersed states, accounting for 51.2% of the US resident population and 49.3% of all US hospitalizations. However, these data do not have any geographical information, and thus cannot be used for regional, state, or hospital-specific analysis.

We identified every adult hospitalization from January 2013 to December 2014 (2-year period) for which the primary procedure code was either TKA or THA. Then, for each of these discharges, we looked at the subsequent 30 days to see if patients were readmitted within that time with a primary diagnosis of post-operative SSI. To identify patients who underwent TKA or THA, we used HCUP's Clinical Classification Software codes 152 and 153, respectively. To identify cases with an SSI, we used the International Classification of Diseases, 9th Revision, Clinical Modification codes 686.8, 686.9, 711.00, 711.05, 711.08, 711.09, 711.40, 711.45, 711.48, 711.49, 711.90, 711.95, 711.98, 711.99, 730.00, 730.05, 730.08-730.10, 730.15, 730.18, 730.19, 730.20, 730.25, 730.28, 730.29, 730.90, 730.95, 730.98, 730.99, 996.60, 996.66, 996.67, 996.69, 998.51, 998.59, and 998.6, in addition to patients listed as undergoing the International Classification of Diseases, 9th Revision, Clinical Modification procedures 84.56, 86.01, 86.04, 86.22, and 86.28 [27]. We applied discharge weights provided by HCUP to aggregate to national readmission rates and to account for yearly changes in the sampling design.

Statistical Analysis

We used logistic regression to estimate the odds of being readmitted for an SSI within 30 days using 3 models: a model for TKAs only, a model for THAs only, and a pooled model. We considered the following patient-level covariates: age (grouped by decade), gender, length-of-stay (with a log transformation to account for high skew), Elixhauser Comorbidity Index (a series of 29 indicators), the number of diagnoses on the record, the number of procedures on the record, and patient location (urban/rural). Patient location was dichotomized using the categories provided by HCUP, with urban defined as metropolitan statistical areas with population greater than or equal to 50,000. We also considered the following hospital-level covariates: hospital size (based on the number of beds as defined by HCUP) and teaching/metropolitan status (rural, urban teaching, urban non-teaching). TKA and THA discharges containing missing covariate data were imputed using univariate medians, or subsumed into an "other" category for primary payer status.

To gauge a seasonal effect, we used sine and cosine terms on discharge month in the regression equation. A non-linear transformation of these 2 estimated regression coefficients allows us to calculate and make inferences about the "average amplitude of seasonality" over the course of the study period after controlling for the other covariates in the model (see Statistical Methods in Appendix for details).

Because the NRD does not track patients across years, estimates for 30-day readmission for patients discharged in the month of December will be underestimates: many of these patients will not be readmitted until after January 1, and thus they are censored. To account for this as well as to ensure that our seasonality estimates are not biased, we include an indicator variable for December in the regression equation. This ensures that the effect of December censoring is estimated separately, and that patients discharged in December are not contributing to the estimated seasonality effect.

Finally, we investigated whether the pattern of seasonality differed for specific at-risk populations. Specifically, we focused on patients with diabetes, patients with obesity, and patients with at least one co-morbidity. We tested whether the sine and cosine terms in the regression equation interacted with indicator variables denoting group membership; if these interaction coefficients were significantly different from zero (via likelihood ratio tests), we concluded that the patterns of seasonality were statistically different. For all analyses, we used R 3.3.3.

Results

There were 760,283 procedures (TKA 424,104, THA 336,179) in our sample. When the Agency for Healthcare Research and Quality