

Investigate the role of team consistency score in patients' surgery outcome

Objective:

A systematic review reveals that team consistency is an important component influencing the "relationship between system factors and patient outcomes."¹ To understand the relationship between team structure and operative efficiency is believed to have an important impact on optimization of surgical team structure in high volume surgical fields, such as total joint replacement (TJR). In this study, We built a model to quantify team consistency score and focused on the role of team consistency on operative outcomes.

Primary Exposure:

Defining "consistency" with respect to a surgical team's composition was accomplished through network modeling. The consistency score was calculated as a percentage derived from the fraction of team interactions in which: 1) The denominator was the total number of times all of the surgeon's past team members have worked with the surgeon and each other on that surgeon's operations (i.e. excluding operations led by different surgeons). 2) The numerator was the total number of times the current team members of the surgery in question have worked with the surgeon, and each other, in the past on that particular surgeon's operations. Resulting consistency score calculations were assigned to each surgery accounting for five team roles: surgeon, anesthesiologist, scrub technician, circulating nurse and first assistant.

Surgeon-centric pairwise sub-analyses were also performed, calculating consistency scores for surgeon-first assist, surgeon-anesthesiologist, surgeon-scrub technician and surgeon-circulating nurse pairings.

Methods:

We performed a retrospective cohort study using existing electronic medical record data for patients who had a total hip arthroplasty (THA) or total knee arthroplasty (TKA) between April 1, 2013 and March 31, 2015. We used in-house electronic health records extracted from the Discharge And Billing Module (DBM), the Perioperative Suite (PS) of Picis Clinical Solutions, Inc. (Wakefield, MA) and the Care Management Module (CMM) from Allscripts Healthcare Solutions, Inc. (Chicago, IL) to characterize OR teams and patients. Data from PS and CMM were deterministically linked at admission-level to DBM data to create the final dataset.

Statistical Analysis:

Multivariable regression analyses were performed to analyze the consistency score effect on turnover duration, patient-in-to-procedure-start duration, procedure-end-to-patient-out duration and surgery duration. We controlled for surgeon's years of experience as more experienced surgeons may have shorter surgical processing times due to enhanced surgical and team management skills that are developed over time. Procedure type (THA or TKA) was included in the models to account for differences in surgical procedures and patient characteristics between the two procedures that may

impact surgical processing times. We all also included BMI and Charlson Comorbidity Index to limit differences in surgical processing times due to patient characteristics (e.g. an obese patient may prolong patient-in-to-procedure-start time due to extended positioning time). Logistical variables, flip room, case order and day-of-week were also included in the analyses. Models were adjusted for surgeon clustering effect as each surgery with the same surgeon could not be considered independent from one another. Patients with missing data were excluded from the multivariable regression models.

Results:

We identified 72,898 surgical admissions in PS and 29,474 inpatient surgical admissions in DBM between April 1, 2013 and March 31, 2015. The surgical admissions from PS were deterministically linked to the inpatient surgical admissions from DBM and 29,474 admissions remained after the datasets were linked. Among these visits, we identified 28,514 admissions that did not have multiple OR visits in the same admission and did not have two surgeons performing two separate surgeries during one OR visit. From this population, we identified 14,649 admissions that were THA, TKA or hip resurfacing procedures using ICD9-CM codes from DBM and procedure descriptions in PS. In order to examine surgeries with more uniform and standardized processes, we excluded hip resurfacing procedures, non-traditional THAs and TKAs, and cases involving trauma. Consequently, we analyzed only traditional THA and TKA admissions resulting in a final cohort of 11,010 admissions with 10,315 patients. Figure 2 shows the flow diagram of our final cohort using our patient exclusion criteria.

Demographics of the study population can be seen in Table 1. TKA patients were slightly older and more likely to be obese than THA patients. A majority of the patients had no comorbidities (71.3%), however TKA patients had a comorbidity burden than THA patients. Overall, TKA patients had longer surgical times than THA patients. THA and TKA surgeons had similar years since medical school graduation and THA and TKA surgeries had similar case order, day-of-the-week and flip room distributions.

Six-role and two-role consistency scores were calculated for surgeries from June 29, 2013 to March 31, 2015 to account for the 90-day historical window for calculation of team consistency. Scores were not calculated for surgeries with surgeons who did not perform 10 or more surgeries in the prior 90 days. This resulted in consistency score calculations for 9,429 TKA and THA surgeries (see Table 1). Using turnover time, patient-in-to-procedure-start time, procedure-end-to-patient-out time and length of surgery as outcomes, and SSLR methodology, six-role consistency scores were categorized into five, eight, four and six groups (see Table 2), respectively. Using the same methodology, two-role consistency scores were also categorized into groups (see Supplementary materials).

The multivariable models presented in Table 3 support the hypothesis that surgical teams with team members who worked together more frequently had shorter surgical processing times for THA and TKA procedures at this institution during the study time period. There was a significant 17.5 minute decrease ($p < 0.05$) in length of surgery with a consistency score greater than 31.5% compared to surgeries with a score of 0.9% or below (i.e., if more than 31.5% of the surgeon's network interactions from the last 90 days are among the current team members, the surgical length will be 17.5 minutes shorter than surgeries where 0.9%, or fewer, of the surgeon's network interactions from the last 90 days are among the current team members). There was a 7.0 minute decrease in patient-in-to-procedure-start duration when surgeries had a consistency score higher than 19.3% compared to surgeries with a score of 0.7% or below. Similarly, time from procedure-end to patient-out, was 1.0 minute less when surgeries had a consistency score more than 35.8% compared to surgeries with a score of 13.5% or below.

The results from the sub-analyses support the hypothesis that frequent pairing of individual team members with a surgeon improves surgical processing times for that surgeon's whole team (see Supplemental Materials). For surgeon-first assist pairings, there was a 22.9 minute decrease in surgery

duration for operations with consistency scores greater than 86.4% compared to those scoring 8.7% or less. For surgeon-second assist pairings, there was an 11.5 minute decrease in surgery duration for operations with consistency scores greater than 72.8% compared to those scoring 0.7% or less. For surgeon-anesthesiologist pairings, there was a 13.1 minute decrease in “patient-in-room” to “procedure-start” time for surgeries with scores higher than 68.6% versus surgeries with 0.5% or less.

Discussion:

This analysis of retrospective data from over 9,000 TKA and THA cases from a single musculoskeletal hospital reveals that frequent surgical team interactions shorten surgical processing times, even when accounting for potential confounders such as patient BMI, Charlson Comorbidity Index and age, surgical factors such as surgeon experience and procedure type, and logistics such as flip room, case order and the day of the week.

Figure 1: Consistency Score Calculation

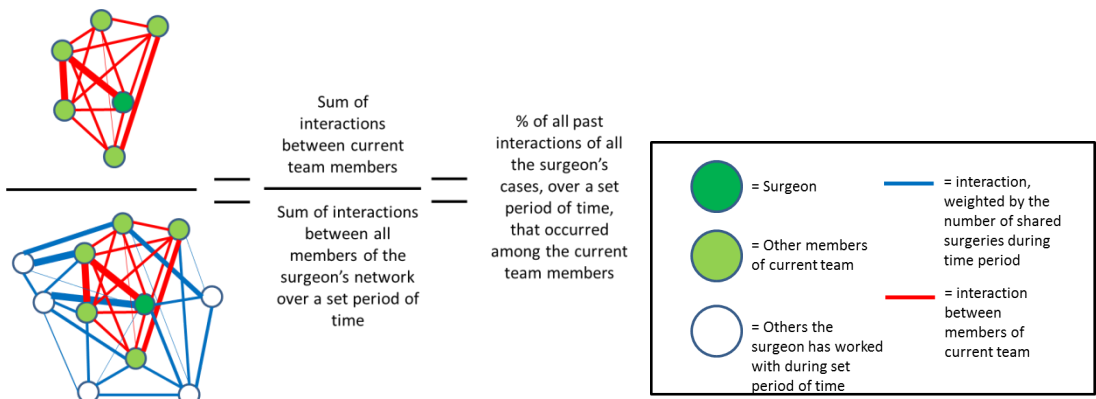


Figure 2: Derivation of final cohort using the patient exclusion criteria

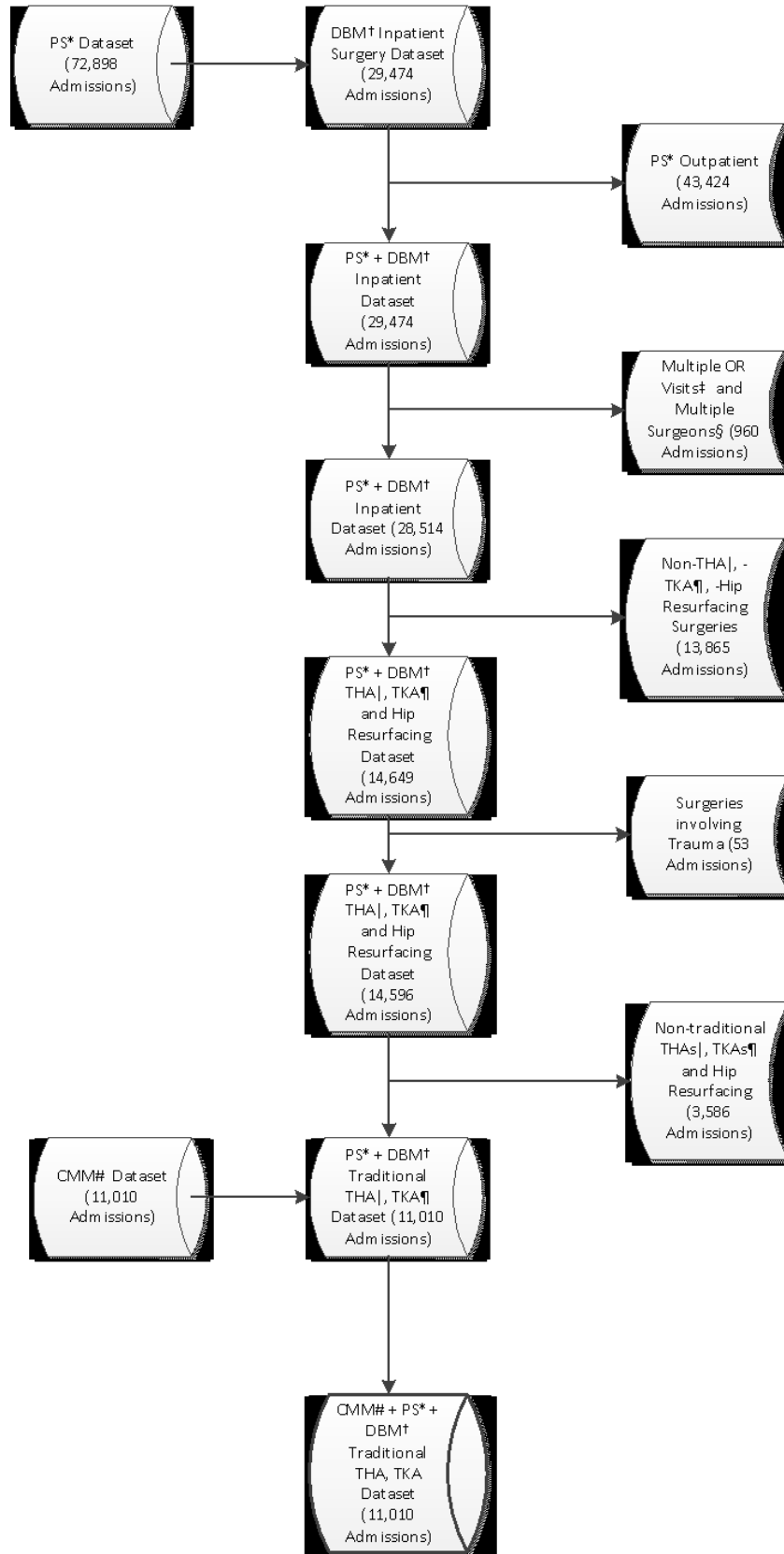


Figure 2 Legend: *Perioperative Suite, Picis Clinical Solutions, Inc., †Eagle HMS Discharge And Billing Module, ‡Multiple OR visits in the same admission, §Multiple surgeons performing separate procedures during the same OR visit, |Total Hip Arthroplasty, ¶Total Knee Arthroplasty, #Allscripts Care Management Module

Table 1: Patient Demographics, Study Population & Surgery Characteristics

	THA and TKA (Mean +/- SD or n, %) n = 11010	THA (Mean +/- SD or n, %) n = 5568	TKA (Mean +/- SD or n, %) n = 5442
Age, yrs	66.6+/-10.1	65.2+/-11.5	68.0+/-9.4
Missing	0	0	0
BMI	29.6+/-6.1	28.4 +/-5.7	30.8+/-6.3
Underweight/Normal (BMI < 25)	2153 (19.6)	1383 (24.8)	770 (14.2.7)
Overweight (25 ≤ BMI < 30)	3555 (32.3)	1879 (33.8)	1676 (30.8)
Obese (BMI ≥ 30)	3925 (35.7)	1623 (29.2)	2302 (42.3)
Missing*	1377 (12.5)	683 (12.3)	694 (12.8)
Charlson Comorbidity Index			
0	7848 (71.3)	4168 (74.9)	3680 (67.6)
1	2304 (20.9)	1011 (18.2)	1293 (23.8)
≥2	858 (7.8)	389 (7.0)	469 (8.6)
Missing	0	0	0
Length of surgery, mins	78.3+/-20.1	73.8+/-19.5	83.0+/-19.5
Missing	0	0	0
Turnover time, mins	43.7+/-31.5	42.6+/-29.3	44.7+/-33.4
Missing†	5485 (49.8)	2878 (51.7)	2607 (47.9)
Patient-in-to-cut time, mins	42.1+/-11.6	41 +/-11.6	43.1+/-11.4
Missing	63 (0.01)	30 (0.01)	33 (0.01)
Close-to-patient-out time, mins	6.0+/-3.9	5.9+/-3.6	6.2+/-4.1
Missing	59 (0.01)	36 (0.01)	23 (0.004)
Years since graduation date	28.8 +/- 10.2	29.4 +/- 10.9	28.3 +/- 9.3

Missing	0	0	0
Flip room	6854 (62.3)	3250 (58.4)	3604 (66.23)
Missing	0	0	0
Case order			
1-3	6902 (62.7)	3815 (68.5)	3087 (56.7)
4-6	3575 (32.5)	1534 (27.6)	2041 (37.5)
7-11	533 (4.9)	219 (3.9)	314 (5.8)
Missing	0	0	0
Day of the week‡			
Monday	2942 (26.7)	1250 (22.5)	1692 (31.1)
Tuesday	2000 (18.2)	1273 (22.9)	727 (13.4)
Wednesday	2622 (23.8)	1236 (22.2)	1386 (25.5)
Thursday	1803 (16.4)	1027 (18.4)	776 (14.3)
Friday	1440 (13.1)	677 (12.2)	763 (14.0)
Saturday	203 (1.8)	105 (1.9)	98 (1.8)
Missing	0	0	0
Six-role consistency score	0.10+/-0.09	0.11+/-0.09	0.09+/-0.08
Missing§	1581 (14.4)	795 (15.9)	781 (16.4)
Surgeon-first assist consistency score	0.16+/-0.18	0.17+/-0.19	0.16+/-0.17
Missing§	1647 (15.0)	823 (14.8)	824 (15.1)
Surgeon-second assist consistency score	0.32+/-0.26	0.33+/-0.26	0.30+/-0.26
Missing§	1880 (17.1)	914 (16.4)	966 (17.8)
Surgeon-anesthesiologist consistency score	0.11+/-0.14	0.11+/-0.15	0.10+/-0.14
Missing§	1581 (14.4)	794 (14.3)	787 (14.5)

Surgeon-scrub technician consistency score	0.18+/-0.18	0.20+/-0.19	0.16+/-0.17
Missing§	1616 (14.7)	815 (14.6)	801 (14.7)
Surgeon-circulating nurse consistency score	0.19+/-0.19	0.22+/-0.20	0.17+/-0.18
Missing§	1581 (14.4)	794 (14.3)	787 (14.5)

*BMI data for admissions in 2015 were cost prohibitive to retrieve.

†Turnover time was associated with the subsequent surgery rather than the previous surgery. Thus, first surgeries of the day did not have a turnover time. Also, turnover time was only calculated for surgeries that had the same surgeon on the previous surgery in the OR where the surgery took place

‡No surgeries were performed on Sunday.

§Only surgeries that had data on surgical team relationships 90 days prior had a consistency score. Thus, surgeries occurring within the first 90 days of the dataset or surgeries with a team member who did not have complete information on surgical team relationships 90 days prior did not have an associated consistency score.

Table 2: SSLR* Derived Categorizations for Consistency Score

Outcome Measure	Consistency Score Cutpoint	N (%)
Turnover Duration	Cut1 (≤ 0.012)	511 (5.4)
	Cut2 ($>0.012, 0.149$)	7218 (76.6)
	Cut3 ($>0.149, 0.263$)	1199 (12.7)
	Cut4 (>0.263)	501 (5.3)
Patient-In-to-Procedure-Start Duration	Cut1 (≤ 0.007)	296 (2.9)
	Cut2 ($>0.007, 0.030$)	1430 (15.2)
	Cut3 ($>0.030, 0.109$)	4564 (48.4)
	Cut4 ($>0.109, 0.146$)	1364 (14.5)
	Cut5 ($>0.146, 0.193$)	811 (8.6)
	Cut6 ($>0.193, 0.382$)	838 (8.9)
Procedure-End-to-Patient-Out Duration	Cut7 (>0.382)	153 (1.6)
	Cut1 (≤ 0.135)	7284 (77.3)
	Cut2 ($>0.135, 0.358$)	1939 (20.6)
Surgery Duration	Cut3 (>0.358)	206 (2.2)
	Cut1 (≤ 0.009)	339 (3.6)
	Cut2 ($>0.009, 0.028$)	1154 (12.2)
	Cut3 ($>0.028, 0.055$)	1854 (19.7)
	Cut4 ($>0.055, 0.315$)	5775 (61.3)
	Cut5 (>0.315)	307 (3.3)

*Stratum-specific likelihood ratio

Table 3: Multivariable Regression Models

Outcome	Predictor	Coef (95% CI)	p-value
Turnover Duration, mins	Consistency scores		
	Cut1 (≤ 0.012)	ref	
	Cut2 ($> 0.012, 0.149$)	1.12 (-5.15, 7.39)	0.720
	Cut3 ($> 0.149, 0.263$)	-0.69 (-6.98, 5.59)	0.825
	Cut4 (> 0.263)	1.83 (-8.03, 11.68)	0.710
	Years since graduation	0.129 (-0.041, 0.299)	0.133
	Procedures		
	THA*	ref	
	TKA†	1.35 (-1.90, 4.59)	0.407
	Age, yrs	-0.01 (-0.10, 0.09)	0.895
	BMI		
	Underweight/Normal (BMI < 25)	ref	
	Overweight ($25 \leq$ BMI < 30)	1.00 (-1.28, 3.28)	0.380
	Obese (BMI ≥ 30)	2.32 (-0.11, 4.76)	0.061
	Charlson Comorbidity Index		
	0	ref	
	1	1.46 (-0.70, 3.62)	0.180
	≥ 2	0.76 (-3.82, 5.33)	0.740
	Flip room		
	No	ref	
	Yes	-2.05 (-5.76, 1.67)	0.273

Case order			
1-3	ref		
4-6	7.56 (5.68, 9.45)	<0.001	
7-11	7.81 (4.11, 11.51)	<0.001	
Day of the week			
Monday	ref		
Tuesday	1.82 (-3.15, 6.79)	0.464	
Wednesday	2.83 (-1.84, 7.49)	0.229	
Thursday	1.79 (-2.73, 6.31)	0.429	
Friday	0.448 (-4.191, 5.086)	0.846	
Saturday	-5.60 (-12.21, 1.02)	0.095	
Patient-In-to-Pro cedure-Start Duration, mins	Consistency Scores		
	Cut1 (≤ 0.007)	ref	
	Cut2 ($> 0.007, 0.030$)	0.01 (-1.58, 1.61)	0.987
	Cut3 ($> 0.030, 0.109$)	-2.35 (-4.25, -0.45)	0.016
	Cut4 ($> 0.109, 0.146$)	-4.16 (-7.08, -1.24)	0.006
	Cut5 ($> 0.146, 0.193$)	-5.67 (-8.85, -2.49)	0.001
	Cut6 (> 0.193)	-7.03 (-11.56, -2.49)	0.003
	Years Since Graduation	0.02 (-0.12, 0.15)	0.796
	Procedures		
	THA*	ref	
	TKA†	1.19 (-0.23, 2.60)	0.098
	Age, yrs	0.001 (-0.036, 0.038)	0.956
	BMI		
	Underweight/Norm al (BMI < 25)	ref	

	Overweight ($25 \leq \text{BMI} < 30$)	0.42 (-0.02, 0.86)	0.060
	Obese ($\text{BMI} \geq 30$)	1.94 (1.38, 2.51)	<0.001
	Charlson Comorbidity Index		
	0	ref	
	1	0.53 (-0.04, 1.09)	0.065
	≥ 2	1.20 (0.17, 2.22)	0.023
	Flip room		
	No	ref	
	Yes	6.94 (4.56, 9.33)	<0.001
	Case order		
	1-3	ref	
	4-6	-2.21 (-3.33, -1.10)	<0.001
	7-11	-4.86 (-7.44, -2.28)	<0.001
	Day of the week		
	Monday	ref	
	Tuesday	2.01 (-1.85, 5.87)	0.299
	Wednesday	1.61 (-1.04, 4.23)	0.227
	Thursday	1.96 (-0.66, 4.58)	0.138
	Friday	2.15 (-1.50, 5.80)	0.243
	Saturday	-4.58 (-7.12, -2.03)	0.001
Procedure-End-to-Patient-Out Duration, mins	Consistency Scores		
	Cut1 (≤ 0.135)	ref	
	Cut2 ($> 0.135, 0.358$)	-0.43 (-0.83, -0.04)	0.032
	Cut3 (> 0.358)	-1.02 (-1.91, -0.13)	0.026
	Years Since Graduation	-0.02 (-0.04, -0.01)	0.025

Procedures		
THA*	ref	
TKA†	0.14 (-0.15, 0.42)	0.340
Age, yrs	-0.01 (-0.02, 0.01)	0.273
BMI		
Underweight/Normal (BMI < 25)	ref	
Overweight (25 ≤ BMI < 30)	0.04 (-0.18, 0.26)	0.691
Obese (BMI ≥ 30)	0.16 (-0.07, 0.38)	0.163
Charlson Comorbidity Index		
0	ref	
1	0.12 (-0.12, 0.35)	0.315
≥2	0.46 (0.04, 0.87)	0.031
Flip room		
No	ref	
Yes	-0.18 (-0.56, 0.20)	0.340
Case order		
1-3	ref	
4-6	-0.15 (-0.41, 0.11)	0.263
7-11	-0.50 (-1.23, 0.23)	0.173
Day of the week		
Monday	ref	
Tuesday	-0.15 (-0.79, 0.49)	0.642
Wednesday	-0.08 (-0.61, 0.45)	0.752
Thursday	0.36 (-0.23, 0.95)	0.230
Friday	0.55 (-0.09, 1.20)	0.089
Saturday	0.54 (-0.57, 1.64)	0.334

Surgery Duration, mins	Consistency Scores		
	Cut1 (≤ 0.009)	ref	
	Cut2 ($> 0.009, 0.028$)	-2.88 (-6.61, 0.85)	0.127
	Cut3 ($> 0.028, 0.055$)	-7.50 (-11.34, -3.65)	<0.001
	Cut4 ($> 0.055, 0.315$)	-9.74 (-14.39, -5.10)	<0.001
	Cut5 (> 0.315)	-17.41 (-25.92, -8.90)	<0.001
	Years Since Graduation	0.20 (-0.04, 0.44)	0.099
	Procedures		
	THA*	ref	
	TKA†	8.61 (4.95, 12.26)	<0.001
	Age, yrs	-0.18 (-0.26, -0.09)	<0.001
	BMI		
	Underweight/Normal (BMI < 25)	ref	
	Overweight ($25 \leq$ BMI < 30)	1.78 (0.33, 3.24)	0.018
	Obese (BMI ≥ 30)	6.38 (4.39, 8.37)	<0.001
	Charlson Comorbidity Index		
	0	ref	
	1	0.30 (-0.97, 1.57)	0.639
	≥ 2	0.59 (-1.34, 2.53)	0.540
	Flip room		
	No	ref	
	Yes	-1.28 (-4.67, 2.12)	0.452
	Case order		
	1-3	Ref	
	4-6	0.52 (-1.39, 2.43)	0.585

7-11	0 (-4.85, 3.04)	0.646
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Day of the week		
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Monday	ref	
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Tuesday	3.95 (-5.74, 13.63)	0.416
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Wednesday	7.16 (0.52, 13.80)	0.035
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Thursday	4.95 (-1.64, 11.53)	0.137
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Friday	4.59 (-2.74, 11.91)	0.214
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Saturday	-4.99 (-12.33, 2.36)	0.178
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*Total hip arthroplasty

†Total knee arthroplasty

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