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MEDICAID INSURANCE STATUS PREDICTS POSTOPERATIVE MORTALITY AFTER TOTAL KNEE ARTHROPLASTY IN STATE INPATIENT DATABASES

A Thesis in

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Abstract

Background: Social determinants of health, such as primary insurance status, may unduly impact morbidity and mortality after joint surgery. We hypothesized that Medicaid versus private primary insurance status predicts in-hospital mortality after total knee arthroplasty (TKA).

Methods: We build regression models using generalized estimating equations with exchangeable correlation to test our hypothesis in patients in the State Inpatient Database from five states, who underwent primary TKA from January 2007 to December 2014.

Results: Medicaid patients had greater odds of in-hospital mortality compared to patients with private insurance (OR 1.73, 95% CI 1.01 - 2.95). Corroborating our primary analysis as potential mediators, Medicaid patients were also more likely to experience any postoperative complications (OR 1.25, 95% CI 1.18 - 1.33), pulmonary complications (OR 1.26, 95% CI 1.16 - 1.36), infection-related complications (OR 1.51, 95% CI 1.35 - 1.68), intraoperative complications (OR 1.25, 95% CI 1.03 - 1.52), longer length of stay (OR 1.09, 95% CI 1.08 - 1.10), and greater total charges (OR 1.03, 95% CI 1.02 - 1.04) relative to privately insured patients.

Conclusion: Medicaid insurance status is associated with higher in-hospital mortality and morbidity in patients after TKA compared to private insurance, even after controlling for potentially confounding patient characteristics and risk factors.

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Abbreviations

ACA - Affordable Care Act

ANOVA - Analysis of variance

CI - confidence intervals

CBSA - Core Based Statistical Area

GEEs - generalized estimating equations

GLMM - generalized linear mixed model

HRRP - Hospital Readmissions Reduction Program

ICD-9-CM - International Classification of Diseases, Ninth Revision, Clinical Modification

LOS - length of stay

SES - socioeconomic status

OR - odds ratio

SID - State Inpatient Database

TKA - total knee arthroplasty

UTKA - Unilateral-TKA

BTKA - Bilateral-TKA

Preface

My contributions to my thesis include conducting an exhaustive literature review, summarizing conclusions from the analyzed patient data, developing hypotheses for future study, and constructing the entire final manuscript. In addition, I am incredibly grateful to the co-authors of the manuscript, including my mentor, Michael Andreae, who helped me in formulating conclusions from the data and develop the manuscript, Robert White and Zachary Turnbull who developed the initial study hypothesis and retrieved the data necessary for the study, and Licia Gaber-Baylis, who carefully performed our statistical analysis.

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Chapter 1: Introduction

Background

Having any insurance at all is likely better than being uninsured,[1–3] but those who are newly insured by Medicaid still experience major disparities in health care outcomes compared to their privately insured counterparts.[4] Disparities have been demonstrated also in orthopedics; specifically, significant differences in postoperative mortality and morbidity are associated with socioeconomic status, e.g. primary insurance status, as summarized in our literature search (Table 1).[5–12]

Disparities in total knee arthroplasty (TKA), although less studied, are equally of great significance. TKA is a commonly performed procedure in the United States, with an estimated 700,000 cases performed annually, and an expected increase in TKA procedures to 3.48 million by 2030.[13, 14] Minorities and those of lower socioeconomic status (SES) receive TKA at a lower rate and experience a higher rate of TKA-related complications.[15, 16]

A central goal of the Affordable Care Act (ACA) is to increase the number of individuals enrolled in health insurance through the creation of state marketplaces and Medicaid expansions. Since becoming law, it has allowed approximately 20 million non-elderly adults access health insurance.[17] But, underinsured racial/ethnic minority and lower SES patients are more frequently treated at hospitals where the procedure volume is lower; we and others hypothesize that this may explain the disparate outcomes for TKA procedures.[18–21] Lower socioeconomic status may lead to a preferential admission to poor quality, low volume hospitals. Low volume hospitals performing TKAs have poorer outcomes, including a higher risk for infection, pulmonary embolism, revision, and higher mortality rate.[22–25] Furthermore, hospitals that treat a greater proportion of African American and Medicaid patients had higher readmission rates for total hip arthroplasty (THA) and TKA compared to those who treat a relatively lower number of these patients.[26] Social determinants of health are associated in these populations with a greater risk of hospital readmission.[27] Lower SES is often associated with worse health status which induces higher preoperative risk. High risk, low SES populations might benefit most from being treated in high volume high, quality institutions.

Few studies to date examined racial/ethnic or socioeconomic disparities in TKA outside the Medicare population,[7, 9–11, 28–31] in particular with regards to the interaction between SES and surgical volume/quality. Our primary hypothesis is that patients with Medicaid insurance status have higher rates of postoperative mortality after TKA compared to patients with private insurance.

Study objective and hypothesis

Our objectives are to examine the association between primary insurance status, race/ethnicity, median home zip-code income, and hospital volume with patient mortality after TKA in the State Inpatient Database (SID) from New York, Florida, Maryland, Kentucky (2007 - 2014) and California (2007-2011). We furthermore want to explore if social determinants of health (insurance status) interact with treatment in low volume hospitals to compound poor outcomes. Previous research examining insurance type on postoperative outcomes following TKA are presented in Table 1.

Table 1. Review of literature: postoperative outcomes after total knee arthroplasty by primary insurance payer

Study citation	Data source (States, dataset)	Data collection (years)	Sample size (study N)	Outcomes reported (mortality, complications, readmissions, LOS, costs)	Limitations of prior studies
Mistry, JOA[21]	NIS	2009-2013	3,217,056	Use of allogenic transfusions, discharge location, LOS, post-op complications, total cost	Reports differences in use of allogenic transfusions but does not report differences in outcomes between groups
Haghverdian, Arthroplasty Today[6]	Hospital records, skilled nursing facility physical therapy data, California	Nov 2012 - July 2014	80	LOS, distance ambulated	Single state, small sample, limited outcomes reported, only shows Medicare vs. Managed Care insurance
Anthony, JOA[7]	National Readmission Database (from HCUP)	2013-2014	424,104	Readmission rates, SSI	Limited outcomes reported, no mention of race
Adelani, JOA[8]	SID, New York, Florida	Jan 2006 - Sep 2013	340,577	Readmission rates	Limited outcomes comparing primary insurance status
Middleton, JOA[29]	Medicare claims data	2012-2014	360,520 (mortality), 355,155 (complications)	Mortality, complications, readmissions	Only Medicare population
Welsh, JAMDA[30]	Medicare claims data	2009-2011	607,169	Readmissions, discharge setting	Only Medicare population
Schwarzkopf, GOSR[32]	California Hospital Discharge data	2010	28,611	Discharge destination	Single state, single year, limited outcomes reported
El Bitar, JOA[9]	NIS	2009-2011	1,924,432	LOS	Limited outcomes reported
Browne, JBJS[10]	NIS	2002-2011	142,433	Complications, cost, LOS	Compared Medicaid vs non-Medicaid insurance types only
Bolognesi, JBJS[33]	Centers for Medicare & Medicaid Services	Jan 2000 - Dec 2009	65,505	LOS, all-cause mortality, rate of revision or removal	Only Medicare population, outdated
Singh, ARD[31]	MedPAR Part A	1991-2008	2,684,575	LOS, mortality, readmissions	Outdated, only Medicare population, only racial disparities
Rosenthal, JOA[34]	Hospital billing database	Jan 2006 - April 2010	1,695	Knee Society Scores, SSI, rate of follow up	Small sample, single hospital, outdated
Lovald, JOA[35]	Medicare Limited Data Set	1997-2009	53,829	Cost, mortality, complications	Outdated, limited outcomes, only

Cram, JAMA[36]	Medicare Part A data	1991-2010	3,271,851	LOS, readmissions, complications	Medicare population Outdated, only Medicare population
Blum, ACR[12]	Pennsylvania Health Care Cost Containment Council data	2001-2007	17,385	Complications, mortality, revisions	Outdated, limited comparisons of primary payer type
Webb, Orthopedics[37]	Single surgeon split practice data	Jan 2002 - Dec 2005	483	SSI	Small sample, single provider, limited outcomes, outdated

We performed a literature search for database and registry studies investigating social determinants of health in orthopedic surgery using the Medical Subject Headings (MeSH) used by the National Library of Medicine. The MeSH terms that used to produce the search on PubMed were: ((total knee replacement) OR (total joint arthroplasty) OR (total knee arthroplasty) OR (81.54)) AND ((health insurance) OR (payer type) OR (primary payer) OR (healthcare disparities)) AND ((mortality) OR (complications) OR (morbidity) OR (patient readmission) OR (readmission) OR (length of stay) OR (resource utilization) OR (outcomes)).

Chapter 2: Methods

We build regression models using generalized estimating equations (GEEs) with exchangeable correlation to test our hypothesis in patients included in the SID from New York, Florida, Maryland, and Kentucky who underwent primary total knee arthroplasty from January 2007 through December 2014 to investigate the association of insurance type with postoperative outcomes, primarily focusing on in-hospital mortality, in a mixed effects regression model. The Weill Cornell Medicine Institutional Review Board approved the study and determined that participants' informed consent was not required.

Description of State Inpatient Database

The SID is a database compiles inpatient information from non-federal, as well as non-psychiatric hospitals. Each SID observation represents a unique hospital admission as our unit of analysis. Hospitalization and discharge information was extracted for the SID on patients >= 18 years of age, using 2007-2014 data from New York, Florida, Maryland, and Kentucky. Additionally, 2007-2011 data for California was extracted from the SID, HCUP database. HCUP has established measures used to ensure database quality[38].

Data extraction

We identified patients in SID from New York, Florida, Maryland, and Kentucky who underwent primary total knee arthroplasty from January 2007 through December 2014 using the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) code 81.54. Patients were divided into two groups based on whether they had a unilateral-TKA (UTKA) or bilateral-TKA (BTKA). Records with UTKA contained ICD-9-CM code 81.54 once, whereas BTKA had this code present twice.[39] We excluded patients who underwent concomitant revision of knee replacement (ICD-9-CM 81.55) or who had >2 entries for procedure code 81.54. Additionally, records were excluded if age, gender, post-operative disposition, or insurance status were absent.

The following patient variables were collected: Hospital length of stay (LOS), ICD-9-CM diagnoses and procedures, insurance type or expected payer, dates of admission and discharge, and patient disposition. Additionally, the following surgical and hospital variables were collected: date and location (state) hospital where the procedure was performed, the hospital Core Based Statistical Area (CBSA), hospital surgical volume. The SID marks diagnoses as present-on-admission (POA) in order to indicate comorbidities present prior to surgery from perioperative complications.

We stratified patients into 5 groups based on payer type (or in some cases, expected payer): Medicare (fee-for-service as well as Managed Care patients), Medicaid (also fee-for-service as well as Managed Care patients), Uninsured (including self-pay and if no-charge was reported), Other (including government programs, Title V, CHAMPUS, CHAMPVA, and Worker's Compensation), and Private Insurance (private HMOs and PPOs, commercial carriers, as well as Blue Cross).

The Elixhauser comorbidity index was used to measure patient comorbidities,[40] only selecting those diagnoses marked as POA. We relied on Van Walraven's method for calculating a numeric score based on this index, which we then converted into a categorical variable.[41]

Sample characteristics

The total number of observations obtained for the years 2007-2014 for New York, Maryland, Florida, and Kentucky, and 2007-2011 for California, was 922,819. Within these states, 199,141 TKAs were performed in 2007 with a peak of 136,884 performed in 2010. The number of TKAs then decreased, with 95,737 performed in 2014. In Table 2 and Table 3, respectively, we contrast patient characteristics and hospital characteristics by insurance type using bivariate analysis.

Table 2. Demographic and medical characteristics of patients undergoing total knee arthroplasty according to primary payer group.

Characteristic	Medicare (%)	Medicaid (%)	Private Insurance (%)	Other (%)	Uninsured (%)	Overall (%)	P-value
Total	542,330 (58.8)	29,692 (3.2)	306,340 (33.2)	39,609 (4.3)	4,848 (0.5)	922,819 (100.0)	
Age in years							<.0001
Mean (standard deviation)	72.41 (7.71)	57.65 (9.88)	59.25 (7.40)	58.78 (8.62)	61.44 (10.31)	66.92 (10.15)	
Gender							<.0001
Male	188,513 (34.8)	7,357 (24.8)	121,716 (39.7)	20,757 (52.4)	1,643 (33.9)	339,986 (36.8)	
Female	353,817 (65.2)	22,335 (75.2)	184,624 (60.3)	18,852 (47.6)	3,205 (66.1)	582,833 (63.2)	
Race							<.0001
White	427,932 (78.9)	12,245 (41.2)	238,658 (77.9)	27,308 (68.9)	2,968 (61.2)	709,111 (76.8)	
Black	36,277 (6.7)	5,865 (19.8)	26,809 (8.8)	4,640 (11.7)	706 (14.6)	74,297 (8.1)	
Hispanic	42,914 (7.9)	6,423 (21.6)	18,811 (6.1)	4,101 (10.4)	601 (12.4)	72,850 (7.9)	
Other	22,472 (4.1)	3,941 (13.3)	13,389 (4.4)	1,702 (4.3)	469 (9.7)	41,973 (4.5)	
Missing	12,735 (2.3)	1,218 (4.1)	8,673 (2.8)	1,858 (4.7)	104 (2.1)	24,588 (2.7)	
Year of surgery							<.0001
2007	71,068 (13.1)	3,124 (10.5)	38,815 (12.7)	5,569 (14.1)	565 (11.7)	119,141 (12.9)	
2008	73,180 (13.5)	3,533 (11.9)	41,892 (13.7)	5,446 (13.7)	560 (11.6)	124,611 (13.5)	
2009	75,832 (14.0)	3,770 (12.7)	43,360 (14.2)	5,475 (13.8)	669 (13.8)	129,106 (14.0)	
2010	80,683 (14.9)	4,178 (14.1)	45,426 (14.8)	5,936 (15.0)	661 (13.6)	136,884 (14.8)	
2011	79,005 (14.6)	4,628 (15.6)	45,289 (14.8)	6,141 (15.5)	665 (13.7)	135,728 (14.7)	
2012	52,399 (9.7)	2,963 (10.0)	29,478 (9.6)	3,427 (8.7)	547 (11.3)	88,814 (9.6)	
2013	54,618 (10.1)	3,231 (10.9)	30,572 (10.0)	3,779 (9.5)	598 (12.3)	92,798 (10.1)	
2014	55,545 (10.2)	4,265 (14.4)	31,508 (10.3)	3,836 (9.7)	583 (12.0)	95,737 (10.4)	
State							<.0001

California	135,631 (25.0)	7,564 (25.5)	76,332 (24.9)	12,315 (31.1)	624 (12.9)	232,466 (25.2)	
Florida	193,637 (35.7)	4,755 (16.0)	77,990 (25.5)	9,057 (22.9)	1,425 (29.4)	286,864 (31.1)	
Kentucky	42,416 (7.8)	3,274 (11.0)	30,008 (9.8)	1,871 (4.7)	404 (8.3)	77,973 (8.4)	
Maryland	46,769 (8.6)	2,435 (8.2)	37,401 (12.2)	2,559 (6.5)	389 (8.0)	89,553 (9.7)	
New York	123,877 (22.8)	11,664 (39.3)	84,609 (27.6)	13,807 (34.9)	2,006 (41.4)	235,963 (25.6)	
Median household income state quartile for patient zip code							<.0001
First quartile	114,134 (21.0)	11,450 (38.6)	53,688 (17.5)	8,639 (21.8)	1,112 (22.9)	189,023 (20.5)	
Second quartile	138,946 (25.6)	7,612 (25.6)	73,931 (24.1)	10,467 (26.4)	1,138 (23.5)	232,094 (25.2)	
Third quartile	143,554 (26.5)	5,725 (19.3)	85,030 (27.8)	11,185 (28.2)	1,280 (26.4)	246,774 (26.7)	
Fourth quartile	136,581 (25.2)	3,305 (11.1)	88,292 (28.8)	8,392 (21.2)	846 (17.5)	237,416 (25.7)	
Missing	9,115 (1.7)	1,600 (5.4)	5,399 (1.8)	926 (2.3)	472 (9.7)	17,512 (1.9)	
Elixhauser Index - the Van Walraven Score							<.0001
Median (Q1; Q3)	0 (-1; 0)	0 (-3; 0)	0 (-3; 0)	0 (-3; 0)	0 (-2; 0)	0 (-2; 0)	
Elixhauser Comorbidities							
Congestive heart failure	14,392 (2.7)	561 (1.9)	2,633 (0.9)	397 (1.0)	68 (1.4)	18,051 (2.0)	<.0001
Valvular disease	25,232 (4.7)	416 (1.4)	7,996 (2.6)	789 (2.0)	124 (2.6)	34,557 (3.7)	<.0001
Pulmonary circulation disorders	4,663 (0.9)	145 (0.5)	1,058 (0.3)	145 (0.4)	17 (0.4)	6,028 (0.7)	<.0001
Peripheral vascular disorders	15,702 (2.9)	306 (1.0)	3,120 (1.0)	442 (1.1)	48 (1.0)	19,618 (2.1)	<.0001
Hypertension, uncomplicated	354,772 (65.4)	18,125 (61.0)	173,013 (56.5)	22,344 (56.4)	2,846 (58.7)	571,100 (61.9)	<.0001
Hypertension, complicated	33,302 (6.1)	871 (2.9)	7,220 (2.4)	982 (2.5)	130 (2.7)	42,505 (4.6)	<.0001
Paralysis	697 (0.1)	66 (0.2)	239 (0.1)	30 (0.1)	<11 (<0.2)	<1,043 (0.1)	<.0001
Other neurological disorders	13,027 (2.4)	866 (2.9)	4,113 (1.3)	513 (1.3)	60 (1.2)	18,579 (2.0)	<.0001
Chronic pulmonary disease	80,976 (14.9)	6,735 (22.7)	39,697 (13.0)	5,667 (14.3)	672 (13.9)	133,747 (14.5)	<.0001
Diabetes, uncomplicated	109,089 (20.1)	7,067 (23.8)	49,879 (16.3)	7,626 (19.3)	936 (19.3)	174,597 (18.9)	<.0001
Diabetes, complicated	11,418 (2.1)	472 (1.6)	3,931 (1.3)	471 (1.2)	67 (1.4)	16,359 (1.8)	<.0001
Hypothyroidism	92,570 (17.1)	2,812 (9.5)	38,790 (12.7)	3,946 (10.0)	543 (11.2)	138,661 (15.0)	<.0001

Renal failure	30,715 (5.7)	761 (2.6)	6,455 (2.1)	866 (2.2)	116 (2.4)	38,913 (4.2)	<.0001
Liver disease	4,359 (0.8)	815 (2.7)	3,411 (1.1)	475 (1.2)	61 (1.3)	9,121 (1.0)	<.0001
Peptic ulcer disease excluding bleeding	132 (0.0)	16 (0.1)	41 (0.0)	<11 (<0.0)		<200 (0.0)	<.0001
AIDS/HIV	166 (0.0)	82 (0.3)	70 (0.0)	11 (0.0)	<11 (<0.2)	<340 (0.0)	<.0001
Lymphoma	1,508 (0.3)	29 (0.1)	485 (0.2)	54 (0.1)	<11 (<0.2)	<2,087 (0.2)	<.0001
Metastatic cancer	449 (0.1)	46 (0.2)	211 (0.1)	21 (0.1)	<11 (<0.2)	<738 (0.1)	<.0001
Solid tumor without metastasis	3,140 (0.6)	147 (0.5)	1,114 (0.4)	128 (0.3)	30 (0.6)	4,559 (0.5)	<.0001
Rheumatoid arthritis/ collagen vascular diseases	24,733 (4.6)	1,763 (5.9)	12,067 (3.9)	1,046 (2.6)	206 (4.2)	39,815 (4.3)	<.0001
Coagulopathy	7,436 (1.4)	325 (1.1)	2,788 (0.9)	374 (0.9)	48 (1.0)	10,971 (1.2)	<.0001
Obesity	100,662 (18.6)	8,252 (27.8)	84,490 (27.6)	9,927 (25.1)	1,142 (23.6)	204,473 (22.2)	<.0001
Weight loss	1,034 (0.2)	84 (0.3)	295 (0.1)	40 (0.1)	<11 (<0.2)	<1,464 (0.2)	<.0001
Fluid and electrolyte disorders	17,008 (3.1)	790 (2.7)	6,351 (2.1)	812 (2.1)	120 (2.5)	25,081 (2.7)	<.0001
Blood loss anemia	2,463 (0.5)	141 (0.5)	1,059 (0.3)	128 (0.3)	19 (0.4)	3,810 (0.4)	<.0001
Deficiency anemia	41,169 (7.6)	2,411 (8.1)	16,953 (5.5)	2,250 (5.7)	284 (5.9)	63,067 (6.8)	<.0001
Alcohol abuse	3,946 (0.7)	568 (1.9)	2,890 (0.9)	456 (1.2)	58 (1.2)	7,918 (0.9)	<.0001
Drug abuse	1,898 (0.3)	1,019 (3.4)	1,579 (0.5)	328 (0.8)	56 (1.2)	4,880 (0.5)	<.0001
Psychoses	9,537 (1.8)	1,556 (5.2)	4,353 (1.4)	508 (1.3)	80 (1.7)	16,034 (1.7)	<.0001
Depression	56,866 (10.5)	4,733 (15.9)	36,094 (11.8)	4,457 (11.3)	495 (10.2)	102,645 (11.1)	<.0001

Patient demographic and medical characteristics were tabulated after grouping patients based on primary insurance type. P-values refer to comparisons between primary payer groups. Continuous variables analyzed using analysis of variance; categorical variables analyzed using Pearson chi-square test or Fisher exact test. Percents may not sum to 100 due to rounding and missing values.

Table 3. Hospital characteristics for patients undergoing total knee arthroplasty according to primary payer group.

Characteristic	Medicare (%)	Medicaid (%)	Private Insurance (%)	Other (%)	Uninsured (%)	Overall (%)	P-value
Hospital volume							<.0001
First quartile	132,484 (24.4)	13,168 (44.3)	68,462 (22.3)	12,853 (32.4)	1,582 (32.6)	228,549 (24.8)	
Second quartile	134,758 (24.8)	7,646 (25.8)	75,268 (24.6)	10,369 (26.2)	912 (18.8)	228,953 (24.8)	
Third quartile	139,588 (25.7)	5,632 (19.0)	76,807 (25.1)	8,757 (22.1)	915 (18.9)	231,699 (25.1)	
Fourth quartile	135,500 (25.0)	3,246 (10.9)	85,803 (28.0)	7,630 (19.3)	1,439 (29.7)	233,618 (25.3)	
Core-based statistical listing designation							<.0001
Non-CBSA	21,524 (4.0)	1,659 (5.6)	11,376 (3.7)	1,560 (3.9)	232 (4.8)	36,351 (3.9)	
Micropolitan Statistical Area	34,953 (6.4)	1,896 (6.4)	18,570 (6.1)	2,875 (7.3)	237 (4.9)	58,531 (6.3)	
Metropolitan Statistical Area	484,778 (89.4)	25,910 (87.3)	275,464 (89.9)	35,041 (88.5)	4,163 (85.9)	825,356 (89.4)	
Missing	1,075 (0.2)	227 (0.8)	930 (0.3)	133 (0.3)	216 (4.5)	2,581 (0.3)	

Hospital characteristics were tabulated after grouping by primary insurance type. First quartile hospital volume indicates lowest patient volume. P-values refer to comparisons between primary payer groups. Categorical variables analyzed using Pearson chi-square test or Fisher exact test. Percents may not sum to 100 due to rounding and missing values.

Outcome measures

Our primary outcome measure was in-hospital mortality, measured by the unadjusted rate and adjusted odds ratio (OR).

Secondary outcomes included hospital LOS and postoperative complications, measured as incidence rate ratios and ORs, respectively. The following postoperative complication groups were of interest: intraoperative/procedure related, infectious, wound, pulmonary, urinary, gastrointestinal, cardiovascular, and systemic.

Statistical methods

Patients were first stratified in cohorts by insurance type, to contrast demographic and POA comorbidities across strata. The unadjusted rates of LOS, postoperative complications, in-hospital mortality, and total charges were calculated and compared by insurance status. Analysis of variance (ANOVA) was used to compare continuous variables, and the Pearsons chi-squared test or Fisher's exact test were used to compare categorical variables. Variables that violated assumptions of normality were converted to nonparametric equivalents.

We fit marginal logistics regression models using GEEs with exchangeable correlation in order to measure the influence of insurance type on our primary postoperative outcome in-hospital mortality while controlling for demographic characteristics, comorbidities, and potential confounders. Clustering occurs when individual hospitals repeatedly contribute observations, and GEE models take this into account. We reported ORs with their 95% confidence intervals (CI). In the text and in our tables, we marked instances where the odds ratios and CIs crossed the midline as statistically significant, using an asterisk system (*** denotes where p<=.05, ** p<=.01, * p<=.005). Separate models were developed to analyze our primary outcome of interest (in-hospital mortality) and secondary outcomes (overall and by category post-TKA complication rates). Potential confounders were accounted for in our models, by including demographic characteristics and comorbidities, (significance indicated by p <.05) and patient characteristics such as race, age, gender, and insurance type. Additionally, the models included the van Walraven modified Elixhauser comorbidity index [divided into three categories, less than zero, zero, more than zero], median household income based on patient zip-code, procedure year, and procedure state.

The adjusted effect of insurance type on hospital LOS was examined by fitting a generalized linear mixed model (GLMM) to log-transformed LOS (LOS has a non-normal distribution). We reported regression coefficients with a 95% CI, denoting significance levels using the asterisk system noted above. As with the GEEs, GLMMs take clustering into account in cases where individual hospitals repeatedly contribute observations.

In order to account for potentially unmeasured confounders, the regression models were subjected to several sensitivity analyses. We used the Wald statistic to identify the most significant covariates, and our models were re-estimated after removal of the covariate, so long as there was not a significant attenuation of the effect for Medicaid insurance (<10% attenuation of estimated odds for each outcome) and maintained statistical significance after re-estimation. In each model, the most significant covariate was age (in years).

Statistical significance was set at an alpha of <.05, and all p-values are two-sided. Statistical tests and analysis were conducted using SAS version 9.4 (SAS Institute, Cary, NC).

Chapter 3: Results

Unadjusted outcomes

Our primary outcome measure was unadjusted and adjusted in-hospital mortality by insurance type. During the time period studied, total in-hospital mortality was <655. By payer group, in-hospital mortality totaled 528 for Medicare patients, 17 for Medicaid, and 98 for privately insured patients. The *unadjusted* in-hospital mortality was statistically significantly lower in privately insured patients compared to the Medicare and Medicaid population (P <.0001). We tabulated the unadjusted differences in in-hospital mortality and readmission rates between primary insurance types in Table 4.

Table 4. Outcome measures for patients undergoing total knee arthroplasty according to primary payer group.

Characteristic	Medicare (%)	Medicaid (%)	Private Insurance (%)	Other (%)	Uninsured (%)	Overall (%)	P-value
In-hospital death							<.0001
Yes	528 (0.1)	17 (0.1)	98 (0.0)	<11 (<0.0)	<11 (<0.2)	<665 (0.1)	
30-Day Readmission**	25,325 (5.7)	1,492 (6.5)	8,439 (3.6)	1,400 (4.1)	146 (4.2)	36,802 (5.0)	<.0001
90-Day Readmission**	45,331 (10.2)	2,807 (12.2)	17,669 (7.5)	2,589 (7.7)	279 (8.0)	68,675 (9.3)	<.0001
Length of stay							<.0001
Median (Q1; Q3)	3 (3; 4)	3 (3; 4)	3 (3; 4)	3 (3; 4)	3 (3; 4)	3 (3; 4)	
Total charges in 2016 dollars							<.0001
Median (Q1; Q3)	56,107 (38,251; 76,670)	53,573 (34,417; 76,012)	52,848 (32,604; 73,049)	57,362 (34,368; 81,869)	43,243 (25,463; 64,177)	54,952 (35,882; 75,654)	

In-hospital death, readmission, and length of stay rates were calculated by primary insurance type. P-values refer to comparisons between primary payer groups. **Denominator does not include those whose initial disposition was death nor those without adequate follow-up information.

Adjusted outcomes

The effect of primary payer status on in-hospital mortality was estimated using a logistic regression model, with results shown in Table 5. After controlling for patient characteristics, surgical factors, state, and hospital type, Medicaid patients had a 73% higher odds of in-hospital mortality compared to privately insured patients (OR 1.73, 95% CI 1.01 - 2.95). Self-pay or no charge patients had higher odds of 166% (OR 2.66, 95% CI 1.03 - 6.83). Hence, we refute the null hypothesis that there is no difference in in-hospital mortality between payer groups following TKA.

In-hospital mortality is a rare event. Indeed, our models may be overfitted. However, our findings were corroborated (and likely mediated by) our secondary outcomes, further exploring the effect of primary payer status on patient outcomes after TKA. Compared to privately insured patients, individuals insured by Medicaid were more likely to experience any postoperative

complications (OR 1.25, 95% CI 1.18 - 1.33), pulmonary complications (OR 1.26, 95% CI 1.16 - 1.36), infection-related complications (OR 1.51, 95% CI 1.35 - 1.68), intraoperative complications (OR 1.25, 95% CI 1.03 - 1.52), longer length of stay (OR 1.09, 95% CI 1.08 - 1.10), and greater total charges (OR 1.03, 95% CI 1.02 - 1.04).

The hospitals in our dataset were divided into quartiles based on patient volume, with the first quartile representing the lowest volume. Of all Medicaid patients in this study, 44.3% were treated at hospitals in the first quartile. In comparison, 22.3% of privately insured patients were treated at such hospitals. In-hospital mortality was greatest for hospitals in the first quartile. Using hospitals in the first quartile as the reference, the odds ratio for in-hospital mortality for the second quartile was (OR 0.64, 95% CI 0.52 - 0.79), (OR 0.68, 95% CI 0.54 - 0.86) for the third quartile, and (OR 0.42, 95% CI 0.31 - 0.57) for the fourth quartile.

Stratifying the data by state in our sensitivity analyses led to similar inferences [data not shown] There was no significant difference in the adjusted odds ratio for in-hospital mortality between each state and Florida, except in the case of California which had a significantly lower odds of in-hospital mortality (OR 0.56, 95% CI 0.45 - 0.70).

We performed additional sensitivity analyses: The risk-adjusted odds ratio for Medicaid and length of stay after removing age (OR 1.08, 95% CI 1.07 - 1.10) and total charges in 2016 after removing age (OR 1.03, 95% CI 1.02 - 1.04) were still significantly greater for Medicaid compared to private insurance. Risk-adjusted odds ratios were again calculated after removing California, and the incidence rate ratio for Medicaid patients was still significantly greater for LOS (OR 1.07, 95% CI 1.06 - 1.09) and for total charges (OR 1.02, 95% CI 1.01 - 1.03) (Table 6).

Table 5. Full regression results for risk-adjusted outcomes amongst patients after total knee arthroplasty.

Outcome	Length of stay	Total charges in 2016 dollars	In-hospital mortality	Any complications
Payer Status (reference = Private Insurance)				
Medicare	1.02 (1.01 - 1.02)***	1.01 (1.00 - 1.01)***	1.17 (0.90 - 1.52)	1.09 (1.06 - 1.13)***
Medicaid	1.09 (1.08 - 1.10)***	1.03 (1.02 - 1.04)***	1.73 (1.01 - 2.95)*	1.25 (1.18 - 1.33)***
Self-pay or no charge	1.04 (1.02 - 1.06)***	1.01 (0.99 - 1.03)	2.66 (1.03 - 6.83)*	1.10 (0.95 - 1.28)
Other	1.06 (1.05 - 1.07)***	1.01 (1.00 - 1.02)	0.69 (0.34 - 1.40)	1.07 (1.00 - 1.13)*
Race (reference = White)				
Black	1.06 (1.05 - 1.07)***	1.03 (1.02 - 1.03)***	1.38 (1.04 - 1.82)*	1.10 (1.06 - 1.15)***
Hispanic	1.03 (1.02 - 1.03)***	1.00 (0.99 - 1.00)	0.91 (0.65 - 1.27)	1.00 (0.95 - 1.05)
Other	1.03 (1.02 - 1.03)***	1.01 (1.00 - 1.03)	0.89 (0.59 - 1.32)	1.08 (1.03 - 1.14)***
Missing	1.03 (1.01 - 1.04)***	0.81 (0.72 - 0.90)***	1.39 (0.87 - 2.22)	0.69 (0.62 - 0.78)***
Median income level (reference = First quartile)				
Second quartile	0.99 (0.99 - 0.99)***	0.99 (0.99 - 1.00)*	0.88 (0.70 - 1.10)	1.00 (0.97 - 1.03)
Third quartile	0.98 (0.98 - 0.99)***	0.99 (0.99 - 1.00)***	0.89 (0.72 - 1.11)	0.97 (0.95 - 1.00)

Fourth quartile	0.98 (0.97 - 0.98)***	0.99 (0.98 - 0.99)***	0.92 (0.73 - 1.15)	0.97 (0.94 - 1.00)
Missing	1.00 (1.00 - 1.01)	1.00 (0.99 - 1.01)	0.66 (0.35 - 1.24)	1.04 (0.96 - 1.11)
Hospital volume (reference = First quartile)				
Second quartile	0.89 (0.86 - 0.91)***	0.99 (0.94 - 1.05)	0.64 (0.52 - 0.79)***	0.88 (0.80 - 0.97)*
Third quartile	0.86 (0.82 - 0.89)***	0.96 (0.89 - 1.03)	0.68 (0.54 - 0.86)***	0.79 (0.70 - 0.90)***
Fourth quartile	0.86 (0.82 - 0.90)***	0.88 (0.78 - 0.98)*	0.42 (0.31 - 0.57)***	0.79 (0.66 - 0.95)*
Number of knee procedures (reference = 1 procedure)	1.26 (1.22 - 1.30)***	1.59 (1.56 - 1.62)***	2.38 (1.76 - 3.23)***	1.68 (1.60 - 1.77)***
Age	1.00 (1.00 - 1.00)***	1.00 (1.00 - 1.00)	1.07 (1.06 - 1.08)***	1.02 (1.02 - 1.02)***
Female	1.04 (1.03 - 1.04)***	0.99 (0.99 - 1.00)***	0.51 (0.44 - 0.59)***	0.92 (0.89 - 0.94)***
Year (reference = 2007)				
2008	0.97 (0.97 - 0.98)***	1.03 (1.01 - 1.05)***	0.91 (0.69 - 1.22)	1.39 (1.30 - 1.50)***
2009	0.95 (0.94 - 0.95)***	1.11 (1.09 - 1.13)***	0.81 (0.60 - 1.08)	1.32 (1.22 - 1.42)***
2010	0.92 (0.92 - 0.93)***	1.14 (1.11 - 1.16)***	0.92 (0.70 - 1.21)	1.25 (1.15 - 1.36)***
2011	0.90 (0.90 - 0.91)***	1.14 (1.12 - 1.17)***	0.88 (0.66 - 1.18)	1.16 (1.08 - 1.26)***
2012	0.89 (0.88 - 0.90)***	1.19 (1.16 - 1.23)***	0.67 (0.48 - 0.94)*	1.05 (0.97 - 1.15)
2013	0.86 (0.85 - 0.88)***	1.23 (1.19 - 1.27)***	0.53 (0.37 - 0.77)***	0.97 (0.89 - 1.06)
2014	0.81 (0.79 - 0.83)***	1.26 (1.21 - 1.31)***	0.51 (0.35 - 0.75)***	0.85 (0.76 - 0.94)***
State (reference = Florida)				
California	0.94 (0.91 - 0.97)***	1.30 (1.23 - 1.38)***	0.56 (0.45 - 0.70)***	0.77 (0.69 - 0.85)***
Kentucky	0.96 (0.93 - 0.99)*	0.65 (0.58 - 0.72)***	1.17 (0.88 - 1.55)	1.22 (1.05 - 1.42)**
Maryland	0.91 (0.87 - 0.96)***	0.37 (0.35 - 0.40)***	0.99 (0.72 - 1.36)	1.25 (1.06 - 1.48)**
New York	1.09 (1.06 - 1.13)***	0.59 (0.54 - 0.63)***	0.85 (0.66 - 1.09)	0.87 (0.76 - 0.99)*
Elixhauser index (reference = First quartile)				
Second tertile	0.95 (0.94 - 0.95)***	0.96 (0.96 - 0.97)***	0.62 (0.50 - 0.78)***	0.63 (0.60 - 0.66)***
Third tertile	1.05 (1.04 - 1.05)***	1.03 (1.03 - 1.03)***	2.12 (1.72 - 2.61)***	1.21 (1.17 - 1.24)***

Risk-adjusted outcomes for patients undergoing toal knee arthroplasty, expressed as odds ratios with 95% confidence interval. *** denotes where p<=.005, ** p<=.01, * p<=.05

Table 6. Sensitivity regressions for risk-adjusted outcomes amongst patients after total knee arthroplasty.

Outcome	Length of stay LOS, without age	Total charges in 2016 dollars Total charges in 2016 dollars, without age	LOS, without California	Total charges in 2016 dollars, without California
Payer Status (reference = Private Insurance)				
Medicare	1.07 (1.06 - 1.07)***	1.01 (1.00 - 1.01)**	1.01 (1.01 - 1.02)***	1.00 (1.00 - 1.01)
Medicaid	1.08 (1.07 - 1.10)***	1.03 (1.02 - 1.04)***	1.07 (1.06 - 1.09)***	1.02 (1.01 - 1.03)***
Self-pay or no charge	1.05 (1.02 - 1.07)***	1.01 (0.99 - 1.03)	1.04 (1.02 - 1.07)***	1.01 (0.99 - 1.03)
Other	1.05 (1.05 - 1.06)***	1.01 (1.00 - 1.02)	1.04 (1.03 - 1.05)***	1.00 (0.99 - 1.01)
Race (reference = White)				
Black	1.05 (1.05 - 1.06)***	1.03 (1.02 - 1.03)***	1.06 (1.05 - 1.07)***	1.03 (1.02 - 1.03)***
Hispanic	1.02 (1.02 - 1.03)***	1.00 (0.99 - 1.00)	1.03 (1.02 - 1.04)***	1.00 (0.98 - 1.01)
Other	1.03 (1.02 - 1.04)***	1.01 (1.00 - 1.03)	1.02 (1.01 - 1.03)***	1.01 (0.99 - 1.04)
Missing	1.02 (1.01 - 1.04)***	0.81 (0.72 - 0.90)***	1.04 (1.01 - 1.07)**	0.70 (0.59 - 0.84)***
Median income level (reference = First quartile)				
Second quartile	0.99 (0.99 - 1.00)***	0.99 (0.99 - 1.00)*	0.99 (0.99 - 1.00)***	1.00 (0.99 - 1.00)
Third quartile	0.99 (0.98 - 0.99)***	0.99 (0.99 - 1.00)***	0.98 (0.98 - 0.99)***	0.99 (0.99 - 1.00)***
Fourth quartile	0.98 (0.97 - 0.98)***	0.99 (0.98 - 0.99)***	0.98 (0.97 - 0.98)***	0.99 (0.98 - 1.00)***
Missing	1.00 (0.99 - 1.01)	1.00 (0.99 - 1.01)	1.01 (1.00 - 1.02)*	1.00 (0.99 - 1.01)
Hospital volume (reference = First quartile)				
Second quartile	0.89 (0.87 - 0.92)***	0.99 (0.94 - 1.05)	0.91 (0.88 - 0.94)***	0.99 (0.92 - 1.07)
Third quartile	0.86 (0.83 - 0.89)***	0.96 (0.89 - 1.03)	0.88 (0.85 - 0.91)***	0.96 (0.89 - 1.04)
Fourth quartile	0.86 (0.83 - 0.90)***	0.88 (0.78 - 0.98)*	0.87 (0.83 - 0.90)***	0.89 (0.79 - 0.99)*
Number of knee procedures (reference = 1 procedure)	1.25 (1.21 - 1.30)***	1.59 (1.56 - 1.62)***	1.26 (1.21 - 1.32)***	1.60 (1.57 - 1.63)***
Age			1.00 (1.00 - 1.00)***	1.00 (1.00 - 1.00)
Female	1.04 (1.03 - 1.04)***	0.99 (0.99 - 1.00)***	1.03 (1.03 - 1.04)***	0.99 (0.99 - 1.00)***
Year (reference = 2007)				
2008	0.97 (0.97 - 0.98)***	1.03 (1.01 - 1.05)***	0.98 (0.97 - 0.98)***	1.03 (1.01 - 1.05)**
2009	0.95 (0.94 - 0.95)***	1.11 (1.09 - 1.13)***	0.96 (0.95 - 0.96)***	1.10 (1.07 - 1.12)***
2010	0.92 (0.92 - 0.93)***	1.14 (1.11 - 1.16)***	0.94 (0.93 - 0.95)***	1.13 (1.10 - 1.16)***
2011	0.90 (0.89 - 0.91)***	1.14 (1.12 - 1.17)***	0.92 (0.91 - 0.93)***	1.14 (1.11 - 1.17)***

2012	0.89 (0.88 - 0.90)***	1.19 (1.16 - 1.23)***	0.90 (0.89 - 0.92)***	1.18 (1.15 - 1.22)***
2013	0.86 (0.85 - 0.88)***	1.23 (1.19 - 1.27)***	0.87 (0.86 - 0.89)***	1.22 (1.18 - 1.27)***
2014	0.81 (0.79 - 0.83)***	1.26 (1.21 - 1.31)***	0.82 (0.80 - 0.84)***	1.25 (1.20 - 1.30)***
State (reference = Florida)				
California	0.94 (0.91 - 0.97)***	1.30 (1.23 - 1.38)***		
Kentucky	0.95 (0.92 - 0.99)**	0.65 (0.58 - 0.72)***	0.96 (0.93 - 1.00)*	0.66 (0.59 - 0.73)***
Maryland	0.91 (0.87 - 0.95)***	0.37 (0.35 - 0.40)***	0.91 (0.87 - 0.95)***	0.38 (0.35 - 0.40)***
New York	1.10 (1.06 - 1.13)***	0.59 (0.54 - 0.63)***	1.10 (1.06 - 1.13)***	0.59 (0.54 - 0.63)***
Elixhauser index (reference = First quartile)				
Second tertile	0.95 (0.95 - 0.96)***	0.96 (0.96 - 0.97)***	0.95 (0.94 - 0.95)***	0.96 (0.96 - 0.97)***
Third tertile	1.06 (1.05 - 1.06)***	1.03 (1.03 - 1.03)***	1.05 (1.04 - 1.05)***	1.03 (1.02 - 1.03)***

Sensitivity analysis comparing our initial regression analyses. *** denotes where p<=.005, ** p<=.01, * p<=.05

Chapter 4: Discussion

In our regression analysis of SID patients from New York, Florida, Maryland, California and Kentucky who underwent primary total knee arthroplasty from January 2007 through December 2014, Medicaid insurance status was associated with higher unadjusted rate and risk-adjusted odds of mortality. Corroborating our primary outcome, Medicaid patients also experience higher odds of any postoperative complications, as well as pulmonary complications, infectious complications, intraoperative complications, and longer length of stay compared to privately insured patients. We hypothesize that these complications mediated the higher mortality in the Medicaid population. Our findings, however, are *not* to suggest that being insured by Medicaid is detrimental. To the contrary, having Medicaid insurance is probably better than having no insurance at all.[42–44] Although major disparities exist in health outcomes between those insured by Medicaid and private insurance, expanding access to care through the ACA's Medicaid Expansion program is leading to a decrease in the deeply entrenched disparities in access to care between socioeconomic groups in the United States.[45]

Implications and significance

This is the first direct comparison between Medicaid and private insurance type, demonstrating increased mortality after TKA in underinsured patients while controlling for patient characteristics, co-morbidity, risk factor, and age. The mortality data is deeply concerning, given that the data are from several state databases, including several diverse large states (California, Florida, Maryland, Kentucky, and New York), drawing from a significant portion of the US populations and hence likely representing a general trend across the country.

Beyond describing and lamenting disparate outcomes driven by social determinants of health, we need to explore potential mechanisms with a view to design and implement effective countermeasures.[46] We suspected that hospital volume may be an important mediator which could explain the observed disparities between Medicaid and private insurance patients. Racial/ethnic minorities and Medicaid patients are less likely to be treated at high-volume hospitals when compared to White, privately-insured patients.[20, 47, 48] Patients treated at low-volume hospitals have an increased risk for readmission following TKA,[28] and other studies show that high-volume surgeons and institutions have lower rates of complications and mortality following orthopedic surgery.[49–51] Our study corroborates this exploratory hypothesis, in that LOS, in-hospital mortality, and the odds of any complication were greater in the hospitals in the 1st quartile for hospital volume when compared to greater volume hospitals. The differences in mortality and complication rates between payer groups demonstrated in our study may in part be due to the fact that Medicaid patients are largely treated at low-volume hospitals. This generated a new exploratory hypothesis that hospital volume and quality interact with high risk and lower socioeconomic status to compound morbidity and mortality after major joint replacement, a hypothesis that should be investigated and confirmed in subsequent studies. Additional factors that may contribute to poorer outcomes for Medicaid patients include proxmity of patient home to hospitals, longer waiting period for surgical appointments, and lower baseline range of motion and function, and such factors should be investigated as well.

Mediated for example through (implicit) bias, the racial makeup of Medicaid patients may play a role in the disparities presented in this study. Overall health insurance coverage in 2016 for non-Hispanic Whites was 93.7%, while for Blacks coverage was 89.5%, Asians 92.4%, and Hispanics 84.0%.[52] In terms of Medicaid coverage, Blacks make up 34.1% of the insured

population, Hispanics make up 31.1%, and Whites makes up 16.9% as of 2015.[53] A systematic review showed that racial and ethnic minority groups are at a greater risk for postoperative complications and mortality compared to White patients for spinal and joint replacement procedures.[54, 55]

Of note, the Hospital Readmissions Reduction Program (HRRP), under the ACA, has since 2012 reduced payments for Inpatient Prospective Payment System hospitals with excess 30-day readmissions.[56] Such penalization may disproportionally affect hospitals that treat racial/ethnic minority groups and patients of lower SES since the HRRP model does not differentiate hospitals based on the SES of the patient population.[57] Instead, the Centers for Medicare and Medicaid Services policies could promote the preferential admission of the highest risk patients in the high quality, high volume institutions.

Comparison with the existing literature

We believe this is the most up-to-date, largest recent study examining the effect of insurance type on patient mortality following TKA. Previous studies on TKA focused on disparities in Medicare patients only, were outdated, did not group by insurance type, or were mainly concerned with racial/ethnic disparities (Table 1). Our sample size is large and was extracted from several diverse states, thus allowing us to control for many potential confounding variables.

Our hypothesis, formulated *a priori*, that Medicaid insurance status is associated with a higher rate of postoperative mortality following TKA when compared to privately insured patients, builds on previous studies investigating disparities between Medicaid patients and privately insured patients undergoing other orthopedic interventions.[2, 10, 11]

Nevertheless, the present study corroborates previous research examining disparities in surgical outcomes depending on insurance status,[58] including in orthopedic operations.[9–11, 37] LaPar et al. conducted a large retrospective analysis of 893,658 patients from the Nationwide Inpatient Sample database, examining the role of primary payer status on outcomes in several surgical procedures, including 230,000 THAs, and found that those insured by Medicaid had higher odds of unadjusted mortality, higher costs, and greater length of stay compared to private insurance patients.[59] Our study of 922,819 cases similarly found that in-hospital mortality, length of stay, and total cost were higher for Medicaid patients.

Strength and weaknesses of our analysis

One strength of our study comes from its generalizability. The HCUP dataset is a large, diverse sample that we extracted from several of the most populated states, allowing us to draw useful conclusions that can be generalized to the rest of the country. Since our study takes a large number of patient and hospital factors into account, the results can be applied broadly. Conversely, the results should not be construed to implicate bias by any individual or discrimination in any institution. Instead, further investigation at the provider and institutional level is warranted in order to expose the mechanisms driving patient disparities based on insurance type in our healthcare delivery system.[46]

The results maintained statistical significance when controlling for state, hospital characteristics, and patient demographics in our sensitivity analyses. The results also maintained significance independent of inclusion and exclusion of potential confounders, modeling choices and assumptions. Stratification by state still demonstrated higher mortality in Medicaid populations. Our results are compelling and consistent, considering that Medicaid insurance status was

associated also with higher complication rates and remained so across several statistical models and sensitivity analyses. We report many p-values that are highly statistically significant (<.005), but we acknowledge that statistical significance is less meaningful in such a large sample, since significance is quickly reached in studies with such a large number of observations.[60, 61]

We acknowledge several limitations of our study. Although we attempted to control for confounding variables, we cannot exclude that confounders were unaccounted for in our analyses; these confounders could be contributing to poorer postoperative outcomes for Medicaid patients. Patient risk factors that confer poorer outcomes may be proportionally higher in the Medicaid population, such as obesity, lower level of education, lower income level, and decreased English proficiency and may contribute to a higher risk of adverse outcomes in Medicaid patients.[62, 63] Studies examining social determinants of health in patients undergoing orthopedic surgeries are limited, but those that have been conducted found that Medicaid patients undergoing orthopedic procedures are more likely to smoke tobacco and have a higher rate of obesity.[64, 65] Our results may underestimate the rate of adverse events in patients undergoing TKA since patients are only accounted for if they present with complications to the hospital where the procedure was performed. Intraoperative information is not contained in the database, preventing us from studying whether poorer outcomes for Medicaid patients are associated with particular intraoperative events. Proper event coding in the HCUP database is dependent upon providers using particular medical terminology in free-text case notes,[66] and failure to do so leads to missing and misclassified data.

Perioperative and intraoperative factors may also play a role in the disparities observed in the present study. In anesthesia, social determinants of health appear to play a role in the quality of care provided.[46] The use of regional anesthesia in primary joint arthroplasty has been shown to lead to more favorable patient outcomes.[67–75] No large-scale studies have been performed investigating the disparities in the use of regional techniques between racial and ethnic groups, but a study by Memtsoudis et al. using a database of 382,236 total hip arthroplasty and TKA patients found that neuraxial anesthesia was used in 17% of Black patients and 25% of White patients.[67] Similarly, a study by Patorno et al. using the same database found that in cases of hip fractures, regional anesthesia was used more often in White patients (16%) compared to Black patients (13%).[76] Postoperative care and pain management also contain significant disparities between racial and ethnic groups,[1, 77–79] with minorities suffering from higher pain scores,[80] longer wait times to receive pain treatment,[81] and obtaining lower amounts of pain medication compared to White patients.[82]

In addition to patient and hospital characteristics, provider (implicit) bias may play a role in the disparate outcomes observed also in our population,[46] although it more difficult to clearly demonstrate this effect in more complex health interventions, delivered by multiple teams. Providers may be unaware of implicit biases that could result in disparities in care.[83, 84] Educating practitioners about implicit biases may help alleviate the disparities demonstrated in our study.[85]

In addition to physician education, audit and feedback systems may help to provide objective, real-time reports to physicians about their patient outcomes, stratified by insurance and racial groups. Such systems are shown to be useful in influencing provider behaviors in order to improve patient outcomes.[86, 87] Data collected in the electronic medical record could be delivered to an internal algorithm that calculates a performance feedback report for providers.[87] It could include patient outcomes, grouped by race/ethnicity, insurance type, and median income of the home zip-code of the patient, and allow providers to make adjustments as a result of seeing the disparities in outcomes in their patients.

Chapter 5. Conclusion

In conclusion, patients with Medicaid insurance undergoing primary total knee arthroplasty in New York, Florida, Maryland, California and Kentucky may be at higher risk for perioperative mortality and morbidity than their counterparts who are privately insured, even after controlling for patient characteristics, co-morbidity, risk, and age.

Medicaid patients also experienced greater odds of additional adverse clinical outcomes. Our findings were maintained across several models and sensitivity analyses. Our results suggest that patient insurance status may be a predictor of adverse postoperative outcomes, and could be considered when assessing patient risk factors prior to surgery. The disparities presented in this paper are likely not unique to TKA and may be emblematic of pervasive perioperative health system disparities. Improving access through increased rates of insurance is important, but a more sophisticated view which incorporates patient outcomes as a function of insurance type and local hospital performance is crucial in addressing health disparities.

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