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Medicaid insurance as primary payer predicts increased mortality after total hip replacement in the State Inpatient Databases of California, Florida and New York

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Abstract

Study Objective—To confirm the relationship between primary payer status as a predictor of increased perioperative risks and post-operative outcomes after total hip replacements.

Design—Retrospective cohort study.

Setting—Administrative database study using 2007 – 2011 data from California, Florida, and New York from the State Inpatient Databases (SID), Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality.

Patients—295,572 patients age ≥18 years old who underwent total hip replacement with non-missing insurance data were collected, using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnoses and procedures code (ICD-9-CM code 81.51).

Interventions—Patients underwent total hip replacement.

Measurements—Patients were cohorted by insurance type as either Medicare, Medicaid, Uninsured, Other, and Private Insurance. Demographic characteristics and comorbidities were compared. Unadjusted rates of in-hospital mortality, postoperative complications, LOS, 30-day, and 90-day readmission status were compared. Adjusted odds ratios were calculated for our outcomes using multivariate linear and logistic regression models fitted to our data.

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Main Results—Medicaid patients incurred a 125% increase in the odds of in-hospital mortality compared to those with Private Insurance (OR 2.25, 99% CI 1.01–5.01). Medicaid payer status was associated with the highest statistically significant adjusted odds of mortality, any complication (OR, 1.26), cardiovascular complications (OR, 1.37), and infectious complications (OR, 1.66) when compared with Private Insurance. Medicaid patients had the highest statistically significant adjusted odds of 30-day (OR, 1.63) and 90-day readmission (OR, 1.58) and the longest adjusted LOS.

Conclusions—We found higher unadjusted rates and risk adjusted odds ratios of postoperative mortality, morbidity, LOS, and readmissions for patients with Medicaid insurance as compared to patients with Private Insurance. Our study shows that primary payer status serves as a predictor of perioperative risks and that primary payer status should be viewed as a peri-operative risk factor.

Keywords

Health care; health insurance; health care disparities; primary payer status; total hip replacement; administrative database research

1.0 Introduction

1.1 Background

Health insurance status, as measured by primary payer status, serves as a distinct marker of a patient's socioeconomic standing [1, 2]. Since the enrollment of the Affordable Care Act in October 2013 and Medicaid expansion, an estimated 20 million adults have gained health insurance, causing the uninsured rate among non-elderly adults to decline from 20.3% in 2012–2013 to 11.5% as of early 2016[3]. However, this decline may be at the expense of increasing the underinsured population, which was 23% or 31 million in 2014[4]. Although the underinsured (those whose health insurance benefits do not adequately cover their medical expenses) have better outcomes than the completely uninsured, underinsurance still poses a major problem to our healthcare system [5–7].

Uninsured and underinsured patients have been shown to have worse outcomes following medical care of chronic pain, acute care surgery, and major surgeries, in both adult and pediatric populations [2, 8–13]. Total hip replacements are one of the most commonly performed procedures in the United States with a prevalence estimated at 2.5 million individuals in 2010[14]. LaPar et al. demonstrated that insurance status is an independent risk factor of worse surgical outcomes in total hip replacements from years 2003–2007 [9]; however, apart from studies that are outdated, contain data from only single surgeon, single institution, or single states, do not have clearly delineated insurance cohorts, or have limited post-operative outcomes reported, no major follow up study has analyzed the association of insurance status with postoperative outcomes (mortality, morbidity, resource utilization) after total hip replacements by insurance payer type (Table 1)[5, 9, 15–35].

1.2 Study Objective

We sought to explore social determinants of health influencing mortality after hip surgery by analyzing data from a multistate inpatient database for California, Florida, and New York for the years 2007–2011, updating and expanding the existing literature.

1.3 Study Hypothesis

Our hypothesis was that primary payer status predicts in-hospital mortality after corection for potential confounders in a multivariate logistic regression analysis.

To corroborate the robustness of the association of payer status with outcomes after hip surgery, we explored the association between primary payer status and other additional outcomes, including post-operative complications, hospital total length of stay (LOS), and 30-day and 90-day readmission rates after total hip replacements in additional secondary analyses. We conceptionalized that primary payer status, as a social determiant of health, is a predictor of increased perioperative risks, including in-hospital mortality, and anticipated a significant difference in post-operative outcomes after total hip replacements in patients with Medicaid and with Uninsured patients having the worst outcomes.

2.0 Materials and Methods

2.1 Study Database and Population

We examined hospitalizations and discharge information from adults (age ≥ 18 years) using 2007 – 2011 data from California, Florida, and New York from the State Inpatient Databases (SID), Healthcare Cost and Utilization Project, Agency for Healthcare Research and Quality [36]. All study activities were approved by the Weill Cornell Medical College Institutional Review Board. The SID contains all payer inpatient data from nonfederal, non-psychiatric hospitals. Data is coded so each inpatient hospital admission corresponds to one individual record. Variables abstracted for each admission include demographic information; International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnoses and procedures codes; hospital length of stay (LOS); patient insurance type (or expected payer); admission and discharge dates; and discharge disposition. The SID contains present-on-admission (POA) notifiers for each diagnosis which facilitates delineating preexisting medical comorbidities from perioperative complications. Furthermore, each discharge record contains a unique identification code allowing the linking of patient records to identify not only readmission, but also time to readmission. Validity and internal consistency of the SID data are verified by quality control measures established by HCUP.

Using ICD-9-CM procedure codes, we retrospectively identified records from January 2007 through December 2011 for patients who underwent a total hip replacement (ICD-9-CM code 81.51). Patients were cohorted by insurance type (expected payer) as either Medicare (includes both fee-for-service and managed care Medicare patients), Medicaid (includes both fee-for-service and managed care Medicaid patients), Uninsured (includes no-charge reported or self-pay status), Other (includes Worker's Compensation, CHAMPUS, CHAMPVA, Title V, and other government programs), and Private Insurance (includes Blue Cross, commercial carriers, and private HMOs and PPOs). We were specifically concerned

with outcomes for Medicaid (representing the underinsured population) and the Uninsured as compared to Private Insurance. Comorbid medical conditions were selected from the Elixhauser comorbidity index, including only POA diagnoses [37].

2.2 Primary Outcome

The primary outcome of our study was in-hospital mortality by insurance payer type, as indicated by the unadjusted rate and adjusted odds ratio (OR).

2.3 Secondary Outcomes

Additional secondary outcomes which we explored to corroborate primary payer status as a social determiant of health in additional analysis were the rates and OR of postoperative complications, hospital LOS, and 30-day and 90-day readmission rates by insurance payer type. Postoperative complications of interest included pulmonary, wound, infectious, urinary, gastrointestinal, cardiovascular, systemic, and intraoperative/procedural. Table 2 lists the ICD-9-CM codes for the postoperative complications.

2.4 Statistical Analysis

Demographic characteristics and POA comorbidities were compared for all patients who underwent total hip replacements by insurance type. Unadjusted rates of in-hospital mortality, postoperative complications, LOS, total charges, and 30-day and 90-day readmission status for all patients were compared by insurance type. Continuous variables were compared using analysis of variance (ANOVA) and categorical variables were compared using Pearson's χ 2 test or Fisher's exact test. Nonparametric equivalents were used for variables that violated assumptions of normality.

To examine the effect of insurance type on postoperative outcomes, while adjusting for demographic factors, comorbidities, and other potential confounders, we fit logistic regression models to our data. Odds ratios (ORs) with robust 99% confidence intervals were reported; additionally we indicated in our tables instances where the 99.5% and 99.9% confidence intervals were statistically significant using an asterik system (***denotes where p<=0.001, ** p<=0.005, * p<=0.01). We developed separate models for our outcomes of interest: in-hospital mortality, post-operative complications by complication category and overall, 30-day, and 90-day readmissions. In an effort to take into account potential confounders, the models included demographic characteristics and comorbidities with bivariate baseline testing results of $p \leq 0.05$; or variables, such as age, race, gender, insurance type, median household income of patient's zip code, procedure state, and procedure year that were selected a priori. To prevent model overfitting, we regularized our model and retained only those variables that met the bivariate testing criteria and variables that represented at least either 1% of the total study population or 1% of the individual insurance cohorts (we excluded variables that were rarely reported in our sample population) [38]. Model discrimination was evaluated using the area under the receiver operating characteristics curve (AUC), where AUC values of 1.0 indicate perfect discrimination between outcome groups, while values of 0.5 indicate results equal to chance. In order to examine the adjusted effect of insurance status on hospital length of stay, we fit linear regression models to log transformed length of stay. Estimated regression coefficients with

robust 99% confidence intervals were reported; additionally we indicated in our tables instances where the 99.5% and 99.9% confidence intervals were statistically significant using an asterix system (***denotes where p<=0.001, ** p<=0.005, * p<=0.01). The outcome variable length of stay was log transformed to address non-normal distribution. Our multivariate logistic and linear regression models were re-run with the inclusion of interaction terms for insurance payer type and race and for insurance payer type and median income, separately. To assess differences in model discrimination between the original models (with no interaction terms) and those that included interaction terms, p-values were calculated to compare the two calculated AUC. P-values greater than 0.05 indicate non-significance in difference between model discrimination, which signifies that the models are not significantly different in their prediction abilities.

Our multivariate logistic and linear regression models were re-run stratified by state (California, Florida, and New York) to take into effect the fact that each state has different racial and ethnic population demographics and differences in access to and provisions of Medicaid [39].

Sensitivity analyses for the multivariable regression models was performed to account for a potential unmeasured confounder and resultant spurious results. Each model was re-estimated after removing the most statistically significant covariate as measured by the Wald statistic; as long as the originally observed effect for Medicaid insurance was not substantially attenuated (estimated odds of each outcome was attenuated less than 10%) and remained statistically significant after re-estimation the potential for spurious results is reduced, thus acting to validate the sensitivity of the original model [40]. For each model, age (in years) was determined to be the most highly significant covariate.

Model assumptions of normality and linearity were assessed graphically and statistically; goodness-of-fit testing was performed. All p-values are two sided with statistical significance evaluated at <0.01 alpha level. Statistical tests and analysis were performed using SAS version 9.3 (SAS Institute, Cary, NC).

3.0 Results

3.1 Patient and Hospital Characteristics

During the 5-year study period, from 2007–2011, a total of 297,103 patients underwent a total hip replacement in California, Florida, and New York with 295,579 patients being ≥18 years old. 295,572 patients had non-missing payer data allowing for inclusion in the following statistical analysis. From 2007–2011 there was a continual trend in the absolute amount of total hip replacements performed with 53,752 performed in 2007 and 64,420 performed in 2011. Table 3 shows results of bivariate analysis for patient demographic characteristics, POA comorbidities, surgical, and hospital related characteristics compared by primary payer group. Table 4 shows results of bivariate analysis for hospital characteristics for patients undergoing total hip replacement compared by primary payer group.

Unadjusted outcomes by primary payer group appear in Table 5 and WebTable 1. Total in-hospital mortality was <543 (<0.18%, exact numbers censored because of individual insurance types having mortality numbers <11). This includes <197 inpatient mortalities in California, <190 inpatient moralities in Florida, and <156 inpatient mortalities in New York.

3.2 Adjusted Outcomes

Results of multivariate logistic regression models and multivariate linear regression models overall and by state used to estimate the effect of primary payer status on postoperative outcomes appear in Table 6 and WebTable 2, respectively. After adjustment for the concurrent effects of patient, hospital, and operative factors, Medicaid patients incurred a 125% increase in the odds of in-hospital mortality (our primary outcome of interest; Model AUC 0.788), compared to those with Private Insurance (OR 2.25, 99% CI 1.01–5.01). This is strong evidence to refute our null hypothesis that primary payer status does not predict mortality after hip surgery.

To corroborate the robustness of our results, we explored additionally if the association between social determinants of healthcare and outcomes was consistent in additional analysis for our secondary outcome measures.

Medicaid payer status was associated with the highest statistically significant adjusted odds of mortality, any complication (OR 1.26, 99% CI 1.11–1.43), cardiovascular complications (OR 1.37. 99% CI 1.04–1.81), and infectious complications (OR 1.66, 99% CI 1.35–2.05) when compared with Private Insurance. Medicaid patients had the highest statistically significant adjusted odds of 30-day (OR 1.63, 99% CI 1.45–1.83) and 90-day readmission (OR 1.58, 99% CI 1.44–1.73). Multivariable linear regression models demonstrated that Medicaid payer status was associated with the longest adjusted length of stay.

Results of our multivariate logistic and linear regression models re-run stratified by state showed similar findings to our main results. Adjusted OR for inpatient mortality for the individual states of Florida and New York showed nonsignificant increased effect size; these individual by state models were most likely statistically under powered. Results of our multivariate logistic and linear regression models re-run with the inclusion of interaction terms for insurance payer type and race and for insurance payer type and median income, separately, showed overall model nonsignificance for improvement in model predictability (WebTable 3). Therefore, we are confident in our models that do not have inclusion of interaction terms.

In our sensitivity analysis, the reported risk-adjusted odds ratios between Medicaid payer status and outcomes were not significantly attenuated upon re-estimation with removal of the variables representing age as described above. This suggests that adjustment for a potentially unmeasured confounder would not influence the estimated effect of Medicaid payer status (WebTable 4).

4.0 Discussion

We found that in patients undergoing total hip replacement during the years 2007–2011 in California, Florida, and New York, primary payer status of Medicaid was associated with higher inpatient mortality. Corroborating the robustness of our findings, Medicaid insurance participants had higher unadjusted rates and risk-adjusted odds of, 30-day readmission, 90-day readmission, post-operative complications (overall, cardiovascular alone, infectious alone), and hospital length of stay when compared to patients with Private Insurance. Our results were adjusted for patient demographic factors, state, temporal, surgical, and hospital related factors. Additionally, they were subjected to sensitivity analysis and stratification by state. The consistency and reproducibility of the association between primary payer status also for other health outcomes after total hip replacement, in addtition to the independence of the results on model selection choices in our sensitivity analyses, make our findings robust and compelling.

Our hypothesis was that primary payer status is a predictor of increased in-patient mortality as an indication of prevailing and persistent healthcare disparities [13]. It would be a misinterpretation of the data and our statistical analysis to infer that Medicaid insurance is inferior to no insurance at all [41–43]. In fact, a recent National Bureau of Economic Research working paper shows that early Medicaid eligibility has reduced infant and childhood mortality and disability, which has long-lasting health and economic benefits for recipients [44].

Our findings are consistent with previous research on insurance disparities for major orthopedic surgical operations [9, 36]. LaPar et al. demonstrated, from a national sample of close to 900,000 patients undergoing one of eight major surgical operations from 2003–2007 including 230,000 total hip replacement patients, that Medicaid and Uninsured patients were associated with an increase in risk-adjusted in-hospital mortality, greater adjusted length of stay, and greater total costs compared with Privately insured patients. Our study included over 290,000 patients from 2007–2011 with similar findings of increased in-hospital mortality, post-operative complications, length of stay, and readmissions in patients without Private Insurance [9]. Browne et al. reported that Medicaid patients following primary total joint arthroplasties had a higher risk of in-hospital infections, longer length of stay, higher total cost, a more frequent rate of discharge to inpatient facilities, wound dehiscence, and hematoma or seroma compared to non-Medicaid patients [22].

Despite statistical adjustment our results could potentially be explained or partially explained by confounders including, race, ethnicity, socioeconomic status, and hospital quality. Strong and complex interactions exist between these variables and payer status. Non-Whites and those without Private Health Insurance were found to be less likely to receive care at a high volume hospital and by a high volume surgeon [45–47]; studies have shown that receiving treatment at high volume hospitals and by high volume surgeons correlate positively with better care after joint arthroscopies [48–50]. Haider et al, in a mega review of primary research papers between 1990 and 2011, found that uninsured, underinsured, and low income status predict inadequate access to optimal surgical care and poorer outcomes. They also found that all of the factors above are found at a higher rate

among racial minorities [51]. Additionally, decreased access to health care, poor dieting and increased levels of obesity, lower level of education, and language barriers have all been suggested as correlates to health insurance status [2, 9, 11–13, 52, 53]. All of these various causal pathways are equally concerning and further research must be done to investigate the mechanisms that could lead to these discrepancies we observed in our study [13].

2015 United States census data shows that Blacks, Hispanics, and people with lower household income have lower rates of health insurance coverage and Private Health Insurance coverage than Whites [1]. Additionally, Blacks and Hispanics have a higher rate of Medicaid coverage (34.1% and 31.1%) than Whites (16.9%)[54], findings that are consistent with our data. Nwachukwu et al. found that minority groups, Blacks and Hispanics, after total knee replacements (TKR) and total hip replacements (THR), have worse outcomes within 90 days, particularly in regard to increased mortality and joint infections [55]. Schoenfeld et al. showed that racial and ethnic minority populations have an increased risk for complications and mortality following spinal procedures and joint replacement surgeries [56].

Possible mechanisms behind our findings exist which can be secondary to pre-, intra-, and post-operative conditions. Medicaid and uninsured patients have more comorbidities and have worse preoperative health [30, 34, 57]. Andreae et al demonstrated that social determiants of health impact anesthesia quality [13]. Disparities exist in the type of intraoperative anesthesia and analgesia used during total joint replacement surgeries [58, 59]. Neuraxial anesthesia during major joint procedures has been associated with superior perioperative outcomes [60–63]. However, a study of over 500,000 patients undergoing total knee arthroplasty or total hip arthroplasty from 2006–2010 showed that neuraxial anesthesia was used significantly less in Medicaid and Black patients [58].

Lastly, disparities exist regarding postoperative treatment and pain management [2, 5, 11, 12, 64–69]. Minorities, the uninsured, and the underinsured were found to all have lower post-acute rehabilitation care (PARC) than Whites and the privately insured [5]. Meghani et al. showed that disparities exist in analgesic drug treatments and opioid prescriptions. Minorities have longer wait times to receive analgesia treatment [68], are more likely to have worse Pain Management Index (PMI) scores [66], and receive fewer days' supply of opioid [69].

A possible solution to this problem is to expand on the educational programs for providers on apparent disparities in their own patient populations. In 2016, 305 members of the American Orthopedic Association completed a survey, assessing their knowledge on racial disparities and their perceptions on the underlying causes. Only 12 percent of these surgeons believed that race plays a factor in the quality of care received by patients in general, 9 percent believed there are disparities in orthopedics care, 3 percent in their hospitals, and 1 percent in their own practices [70]. There have also been many studies showing implicit racial bias by physicians [71–74]. Educating physicians about implicit biases has been shown to change behavior and lead to more equal treatment [75].

To our knowledge our study features the most currently available and up-to-date data on this topic; prior studies are more than ten years old, contain data from only single surgeon, single institution, or single states, do not have clearly delineated insurance cohorts, or have limited post operative outcomes reported (Table 1) [5, 9, 15–35]. The large number of patient records allowed us to control for a substantial range of potentially confounding patient and non-patient related variables. We used more stringent criteria to determine statistical significance, but consider P-values less useful for inferences in health services research based on large electronic medical record registries. Instead, the robustness of our findings in multiple sensitivity analyses in a clinically heterogenous and representative database reassure us about the internal validity and the generalizibilty of our findings. The states of California, Florida, and New York are among the top ten populous states in the nation, representing approximately 24.6% of the United States population [76]. The use of the HCUP administrative datasets provides data that is widely generalizable across hospitals and insurance payer types and the resultant findings are not restricted to specialized, experienced centers of excellence only. However, likewise findings from administrative database research may not be directly applicable to individual institutions or centers of care.

Our study has limitations. The accuracy of an administrative dataset is reliant upon accurate and complete clinical coding among clinicians [77]. The use of administrative data sets has the potential for coding errors, including missing data and misclassified data. Administrative datasets lack coding pertaining to relevant qualitative clinical data precluding determination of severity of comorbidities or adverse perioperative outcomes. The HCUP dataset does not include detailed intraoperative information and data. There are no patient identifiers in the SID database and follow-up post discharge can only be performed for patients who are readmitted to the hospital. Therefore events occurring outside the hospital cannot be followed or analyzed. We acknowledge that such a methodology may underestimate the rate of adverse outcomes.

In conclusion, we found that Medicaid patients had higher unadjusted rates and risk-adjusted odds ratios of in-patient mortality after hip replacement than those with Private insurance. Our results were consistent in multiple sensitivity analyses across different related clinical outcomes. Our study suggests that primary payer status serves as either indicator or mediator of healthcare disparity and indicate that primary payer status could be viewed as a pre-operative risk factor for poor postoperative outcomes. Differences in outcomes may reflect broader disparities in the health care system.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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HIGHLIGHTS

- Medicaid patients had increased odds of postoperative complications after total hip replacement.
- Medicaid insurance status may serve as a predictor for increased postoperative risks.
- Differences in outcomes may reflect broader disparities in the health care system.

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Table 1

Review of literature: Total hip replacement post operative outcomes 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
Kurtz, CORR, 2017[16]	Nationwide Readmissions Database (from HCUP)	2013	250,884	Readmission rates	Single year, limited outcomes reported, no mention of race
Tanenbaum, JOA, 2017[17]	NIS	2013	68,644	Incidence of Patient safety indicators (PSIs)	Single year, Grouped outcomes as PSI events without breakdown
Haghverdian, JOA, 2017[15]	Physical therapy data at one skilled nursing facility	2012–2014	114	Functional outcomes, LOS	Single institution, small sample
Memtsoudis, Anesthesiology, 2016[18]	Premier Perspective Database	2006–2013	1,062,152 (Hip and knee)	Use of neuraxial vs general anesthesia	Specific intra-op analysis, not much post-op outcomes
Oronce, Medical Care, 2015[20]	SID, California	2009–2011	58,837	Readmission rates	Single state, limited outcomes reported
Schwarzkopf, GOS, 2015[21]	California Hospital Discharge data set	2010	14,326	Discharge destination	Single state, limited outcomes reported
Lavernia, CORR, 2015[28]	single surgeon, single institution	May 2003 – Nov 2012	564	Post-op pain intensity	Single surgeon, single institution, small sample limited outcomes reported, only race and not insurance
Keeney, JOA, 2015[25]	Hospital admission database	Jan 2006 – Sept 2013	4131	Readmission rates	Single institution, small sample, limited outcomes reported
Paxton, CORR, 2015[26]	Kaiser Permanente Total Joint Replacement Registry	Jan 2009 – Dec 2011	12,030	Readmission rates	Limited outcomes reported
Illingworth, JOA, 2015[24]	NIS	2007–2008	508,150	Inpatient mortality	Limited outcomes reported (only mortality) for disparity analysis
Browne, JBJS, 2014[22]	NIS	2002–2011	191,911	Post-op in-hospital complications, LOS, total cost, discharge location	Only shows Medicaid vs. non-Medicaid, doesn't show readmissions
Girotti, JACS, 2014[23]	Center for Medicare and Medicaid Services	2006–2008	299,023	Readmission rates	Only Medicare population, only racial disparities, limited outcomes reported
Singh, ARD, 2014[27]	US Medicare Program	1991–2008	1,646,310	LOS, readmission rates, discharge location, 30-day mortality, post-op complications	Outdated, only Medicare population, only racial disparities
Lavernia, CORR, 2013[19]	AHCA, Florida Hospital Association	April 2009 – March 2010	27,019	Readmission rates	Single state, Single year, limited outcomes reported
Martin, Orthopedics, 2012[29]	University of Iowa Hospitals and Clinics	Not stated	1,312	No outcomes, only insurance disparity in pre-op assessment	Single hospital, small sample, No outcomes

Study citation	Data Source (States, dataset)	Data Collection (years)	Sample size (study N)	Outcomes reported (mortality, complications, readmissions, LOS, costs)	Limitations of prior studies
Martin, JOA, 2012[30]	University of Iowa Hospitals and Clinics	Not stated	293	Postoperative pain and function scores	Single hospital, small sample,
Warth, IOJ, 2011[34]	University of Iowa Hospitals and Clinics	Jan 2004 – June 2008	874	No outcomes, only insurance disparity in pre-op comorbidities and accessibility	Outdated, single hospital, single surgeon, small sample, no outcomes
Freburger, Arthritis Care & Res, 2011[5]	SID (AZ, FL, NJ, WI)	2005–2006	164,875	Racial disparities in post-acute rehabilitation care	Outdated, limited outcomes reported, no insurance analysis
Lapar, Annals of Surgery, 2010[9]	NIS	2003–2007	893,658 (includes other procedures)	Mortality, LOS, total costs, in-hospital complications	Outdated, no analysis on race
Hinman, JOA, 2008[32]	UCSF Medical Center Data from 3 surgeons	Jan 2000 – May 2005,	224	Operative time, LOS, post-op complications	Outdated, small sample, single hospital, limited surgeons
Zhan, JBJS, 2007[35]	NIS	2003	About 200,000	LOS, total charges, in-hospital deaths, post-op complications	Outdated, only 1 year of data
Bozic, JOA, 2006[31]	MGF, MayoClinic, UCSF Medical Center	Jan 2000 – December 2002	4,485	Discharge to an inpatient extended care facility	Outdated, limited to 3 hospitals, small sample, limited outcomes reported
Mahomed, JBJS, 2003[33]	Medicare claims	June 1995 – June 1996	75, 051	Death within 90 days, readmission, complications	Outdated, only Medicare population

Note: The literature search is Table 1 was performed 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 hip replacement) OR (total joint arthroplasty) OR (total hip arthroplasty) OR (81.51)) 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)).

Table 2

Definition of International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9M) codes for post-operative complications.

Category	Condition	ICD9 code
Cardiovascular		
Supraventricular Arrhythmia		
	Atrial fibrillation and flutter	427.3x
	Atrial fibrillation	427.31
	Atrial flutter	427.32
	Paroxysmal supraventricular tachycardia	427.0x
Myocardial Infarction		
	Acute myocardial infarction	410.xx
	Acute coronary occlusion without myocardial infarction	411.81
	Angina pectoris	413.xx
Postoperative Stroke		
	Iatrogenic cerebrovascular infarction or hemorrhage	997.02
	Subarachnoid hemorrhage	430.xx
	Intracerebral hemorrhage	431.xx
	Other and unspecified intracranial hemorrhage	432.xx
	Occlusion and stenosis of precerebral arteries	433.xx
	Occlusion of cerebral arteries	434.xx
	Transient cerebral ischemia	435.xx
	Transient ischemic attach (TIA), and cerebral infarction without residual deficits	V12.54
	Stroke (cerebrovascular)	V17.1x
Deep venous thrombosis		
	Of deep vessels of lower extremities	451.1x
	Of lower extremities, unspecified	451.2x
	Iliac vein	451.81
	Of unspecified site	451.9x
	Of vena cava	453.2x
	Of other specified veins	453.8
	Of unspecified site	453.9x
	Venous embolism and thrombosis of unspecified deep vessels of lower extremity	453.40
	Venous embolism and thrombosis of deep vessels of proximal lower extremity	453.41
	Venous embolism and thrombosis of deep vessels of distal lower extremity	453.42
Pulmonary Embolism		
	Pulmonary embolism and infarction	415.1x
	Iatrogenic pulmonary embolism and infarction	415.11
	Septic pulmonary embolism	415.12
	Other	415.19

Category	Condition	ICD9 code
Pulmonary		
NPOA[d] Pneumonia		
	Pneumonia, organism unspecified	486.xx
	Pneumococcal pneumonia [Streptococcus pneumoniae pneumonia]	481.xx
	Pneumonia due to other specified bacteria	482.8x
	Pneumonia due to Streptococcus	482.3x
	Bacterial pneumonia unspecified	482.9x
	Pneumonia due to Klebsiella pneumoniae	482.0x
	Pneumonia due to Pseudomonas	482.1x
	Pneumonia due to Hemophilus influenzae [H. influenzae]	482.2x
	Methicillin susceptible pneumonia due to Staphylococcus aureus	482.41
	Other Staphylococcus pneumonia	482.49
	Other gram-negative pneumonia	482.83
	Ventilator associated pneumonia	997.31
Postoperative Acute Pneumothorax		
	Iatrogenic pneumothorax	512.1x
Postoperative Pulmonary Edema		
	Acute edema of lung, unspecified	518.4x
Pulmonary Collapse		
	Pulmonary collapse	518.0x
NPOA Empyema With and Without Fistula		
	With fistula	510.0x
	Without mention of fistula	510.9x
Mechanical Ventilation		
	Continuous invasive mechanical ventilation of unspecified duration	96.70
	Continuous invasive mechanical ventilation for less than 96 consecutive hours	96.71
	Continuous invasive mechanical ventilation for 96 consecutive hours or more	96.72
Noninvasive Ventilation		
	Non-invasive mechanical ventilation	93.90
Tracheostomy		
	Temporary tracheostomy	31.1x
	Other permanent tracheostomy	31.29
	Permanent tracheostomy	31.2x
Infectious		
NPOA Sepsis/Shock		
	Septicemia	038.xx
	Sepsis	995.91
	Severe sepsis	995.92
	Other infection	999.3x

Category	Condition	ICD9 code
	Postoperative shock	998.0x
NPOA Urinary Tract Infection		
	Urinary tract infection, site not specified	599.0x
	Infection of kidney, unspecified	590.9x
NPOA wound infection		
	Infected postoperative seroma	998.51
	Other postoperative infection	998.59
Gastrointestinal		
	Digestive system complications	997.4x
Intraoperative Complications		
NPOA Accidental Puncture or Laceration, Complicating Surgery		
	Accidental puncture of laceration during a procedure	998.2x
NPOA Bleeding Complication Procedure		
	Hemorrhage complicating a procedure	998.11

[a]NPOA: Not present on admission

Table 3

Demographic and medical characteristics of patients undergoing total hip replacement according to primary payer group.

Characteristic	Medicare (%)	Medicaid (%)	Private Insurance (%)	Other (%)	Uninsured (%)	Overall (%)	P-value
	164,927 (55.8)	10,170 (3.4)	110,150 (37.3)	8,023 (2.7)	2,302 (0.8)	295,572 (100.0)	
Patient Demographics							
Age by quartile							<.0001
First quartile (18–57)	7,765 (4.7)	6,941 (68.2)	52,860 (48.0)	4,461 (55.6)	1,163 (50.5)	73,190 (24.8)	
Second quartile (58–66)	20,278 (12.3)	2,445 (24.0)	45,760 (41.5)	2,502 (31.2)	703 (30.5)	71,688 (24.3)	
Third quartile (67–75)	66,752 (40.5)	450 (4.4)	8,073 (7.3)	681 (8.5)	237 (10.3)	76,193 (25.8)	
Fourth quartile (76+)	70,132 (42.5)	334 (3.3)	3,457 (3.1)	379 (4.7)	199 (8.6)	74,501 (25.2)	
Age in years (standard deviation)	73.48 (8.93)	52.23 (11.75)	57.27 (9.17)	56.03 (10.85)	57.37 (12.38)	66.11 (12.42)	<.0001
Female	102,206 (62.0)	5,509 (54.2)	54,687 (49.6)	3,203 (39.9)	1,180 (51.3)	166,785 (56.4)	<.0001
Race							<.0001
White	141,756 (86.0)	4,836 (47.6)	89,317 (81.1)	5,734 (71.5)	1,550 (67.3)	243,193 (82.3)	
Black	7,477 (4.5)	2,162 (21.3)	6,324 (5.7)	818 (10.2)	247 (10.7)	17,028 (5.8)	
Hispanic	7,668 (4.6)	1,899 (18.7)	5,783 (5.3)	704 (8.8)	259 (11.3)	16,313 (5.5)	
Other	4,891 (3.0)	838 (8.2)	4,283 (3.9)	306 (3.8)	165 (7.2)	10,483 (3.5)	
Missing	3,135 (1.9)	435 (4.3)	4,443 (4.0)	461 (5.7)	81 (3.5)	8,555 (2.9)	
Year of surgery							<.0001
2007	30,039 (18.2)	1,626 (16.0)	20,270 (18.4)	1,437 (17.9)	380 (16.5)	53,752 (18.2)	
2008	30,964 (18.8)	1,872 (18.4)	20,606 (18.7)	1,460 (18.2)	388 (16.9)	55,290 (18.7)	
2009	33,431 (20.3)	2,033 (20.0)	21,915 (19.9)	1,573 (19.6)	461 (20.0)	59,413 (20.1)	
2010	34,886 (21.2)	2,247 (22.1)	23,329 (21.2)	1,717 (21.4)	518 (22.5)	62,697 (21.2)	
2011	35,607 (21.6)	2,392 (23.5)	24,030 (21.8)	1,836 (22.9)	555 (24.1)	64,420 (21.8)	
State							<.0001
California	65,882 (39.9)	4,282 (42.1)	48,635 (44.2)	3,435 (42.8)	634 (27.5)	122,868 (41.6)	
Florida	55,850 (33.9)	1,985 (19.5)	26,005 (23.6)	2,458 (30.6)	986 (42.8)	87,284 (29.5)	
New York	43,195 (26.2)	3,903 (38.4)	35,510 (32.2)	2,130 (26.5)	682 (29.6)	85,420 (28.9)	
Median household income of the patient's zip code							

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Characteristic	Medicare (%)	Medicaid (%)	Private Insurance (%)	Other (%)	Uninsured (%)	Overall (%)	P-value
First quartile	28,998 (17.6)	3,539 (34.8)	14,958 (13.6)	1,796 (22.4)	421 (18.3)	49,712 (16.8)	
Second quartile	39,943 (24.2)	2,627 (25.8)	23,694 (21.5)	2,016 (25.1)	545 (23.7)	68,825 (23.3)	
Third quartile	43,906 (26.6)	2,010 (19.8)	30,108 (27.3)	2,061 (25.7)	590 (25.6)	78,675 (26.6)	
Fourth quartile	48,935 (29.7)	1,201 (11.8)	39,101 (35.5)	1,889 (23.5)	482 (20.9)	91,608 (31.0)	
Missing	3,145 (1.9)	793 (7.8)	2,289 (2.1)	261 (3.3)	264 (11.5)	6,752 (2.3)	
Elixhauser Comorbidities							
Congestive heart failure	5,274 (3.2)	196 (1.9)	853 (0.8)	83 (1.0)	25 (1.1)	6,431 (2.2)	<.0001
Valvular disease	8,869 (5.4)	147 (1.4)	2,692 (2.4)	151 (1.9)	41 (1.8)	11,900 (4.0)	<.0001
Pulmonary circulation disorders	1,646 (1.0)	52 (0.5)	256 (0.2)	22 (0.3)	11 (0.5)	1,987 (0.7)	<.0001
Peripheral vascular disorders	5,686 (3.4)	113 (1.1)	1,061 (1.0)	89 (1.1)	31 (1.3)	6,980 (2.4)	<.0001
Hypertension, uncomplicated	98,185 (59.5)	4,399 (43.3)	49,434 (44.9)	3,716 (46.3)	966 (42.0)	156,700 (53.0)	<.0001
Hypertension, complicated	10,032 (6.1)	298 (2.9)	2,051 (1.9)	136 (1.7)	51 (2.2)	12,568 (4.3)	<.0001
Paralysis	362 (0.2)	35 (0.3)	147 (0.1)	<11	<11		<.0001
Other neurological disorders	4,655 (2.8)	317 (3.1)	1,388 (1.3)	124 (1.5)	40 (1.7)	6,524 (2.2)	<.0001
Chronic pulmonary disease	24,832 (15.1)	1,842 (18.1)	11,665 (10.6)	981 (12.2)	254 (11.0)	39,574 (13.4)	<.0001
Diabetes, uncomplicated	22,584 (13.7)	1,247 (12.3)	10,157 (9.2)	936 (11.7)	215 (9.3)	35,139 (11.9)	<.0001
Diabetes, complicated	2,696 (1.6)	97 (1.0)	946 (0.9)	65 (0.8)	32 (1.4)	3,836 (1.3)	<.0001
Hypothyroidism	26,261 (15.9)	573 (5.6)	10,638 (9.7)	612 (7.6)	176 (7.6)	38,260 (12.9)	<.0001
Renal failure	9,592 (5.8)	292 (2.9)	1,978 (1.8)	122 (1.5)	46 (2.0)	12,030 (4.1)	<.0001
Liver disease	1,514 (0.9)	382 (3.8)	1,332 (1.2)	138 (1.7)	57 (2.5)	3,423 (1.2)	<.0001
Pepticulcer disease excluding bleeding	32 (0.0)	<11	13 (0.0)	<11			<0.29
AIDS/HIV	343 (0.2)	166 (1.6)	197 (0.2)	17 (0.2)	<11		<.0001
Lymphoma	796 (0.5)	33 (0.3)	361 (0.3)	20 (0.2)	<11		<.0001
Metastatic cancer	675 (0.4)	72 (0.7)	390 (0.4)	18 (0.2)	18 (0.8)	1,173 (0.4)	<.0001
Solid tumor without metastasis	1,659 (1.0)	84 (0.8)	612 (0.6)	32 (0.4)	21 (0.9)	2,408 (0.8)	<.0001
Rheumatoid arthritis/collagen vascular diseases	7,490 (4.5)	735 (7.2)	3,753 (3.4)	241 (3.0)	69 (3.0)	12,288 (4.2)	<.0001
Coagulopathy	2,584 (1.6)	155 (1.5)	1,075 (1.0)	95 (1.2)	29 (1.3)	3,938 (1.3)	<.0001
Obesity	17,314 (10.5)	1,438 (14.1)	17,169 (15.6)	1,074 (13.4)	228 (9.9)	37,223 (12.6)	<.0001
Weight loss	828 (0.5)	57 (0.6)	147 (0.1)	19 (0.2)	12 (0.5)	1,063 (0.4)	<.0001

Characteristic	Medicare (%)	Medicaid (%)	Private Insurance (%)	Other (%)	Uninsured (%)	Overall (%)	P-value
Fluid and electrolyte disorders	6,750 (4.1)	328 (3.2)	2,074 (1.9)	207 (2.6)	94 (4.1)	9,453 (3.2)	<.0001
Blood loss anemia	1,044 (0.6)	62 (0.6)	520 (0.5)	29 (0.4)	12 (0.5)	1,667 (0.6)	<.0001
Deficiency anemia	15,433 (9.4)	956 (9.4)	6,847 (6.2)	597 (7.4)	182 (7.9)	24,015 (8.1)	<.0001
Alcohol abuse	1,825 (1.1)	482 (4.7)	1,756 (1.6)	233 (2.9)	98 (4.3)	4,394 (1.5)	<.0001
Drug abuse	779 (0.5)	523 (5.1)	714 (0.6)	111 (1.4)	55 (2.4)	2,182 (0.7)	<.0001
Psychoses	2,778 (1.7)	455 (4.5)	1,342 (1.2)	96 (1.2)	46 (2.0)	4,717 (1.6)	<.0001
Depression	14,422 (8.7)	1,242 (12.2)	9,604 (8.7)	752 (9.4)	202 (8.8)	26,222 (8.9)	<.0001

Continuous variables analyzed using analysis of variance; categorical variables analyzed using Pearson chi-square test or Fisher exact test. P-values refer to comparisons between primary payer groups. Mean (standard deviation). Percents may not sum to 100 due to rounding and missing values.

Table 4

Hospital characteristics for patients undergoing total hip replacement according to primary payer group.

Characteristic	Medicare (%)	Medicaid (%)	Private Insurance (%)	Other (%)	Uninsured (%)	Overall (%)	P-value
Hospital volume							<.0001
First quartile	41,465 (25.1)	4,621 (45.4)	23,439 (21.3)	3,133 (39. 1)	812 (35.3)	73,470 (24.9)	
Second quartile	42,078 (25.5)	2,745 (27.0)	26,831 (24.4)	1,908 (23. 8)	417 (18.1)	73,979 (25.0)	
Third quartile	42,376 (25.7)	1,679 (16.5)	27,950 (25.4)	1,573 (19.6)	502 (21.8)	74,080 (25.1)	
Fourth quartile	39,008 (23.7)	1,125 (11.1)	31,930 (29.0)	1,409 (17.6)	571 (24.8)	74,043 (25.1)	
Core-based statistical listing designation							<.0001
Non-CBSA	3,253 (2.0)	209 (2.1)	1,884 (1.7)	255 (3.2)	50 (2.2)	5,651 (1.9)	
Micropolitan Statistical Area	8,846 (5.4)	490 (4.8)	4,702 (4.3)	525 (6.5)	110 (4.8)	14,673 (5.0)	
Metropolitan Statistical Area	152,281 (92.3)	9,188 (90.3)	103,083 (93.6)	7,203 (89. 8)	2,006 (87.1)	273,761 (92.6)	
Missing	547 (0.3)	283 (2.8)	481 (0.4)	40 (0.5)	136 (5.9)	1,487 (0.5)	

Continuous variables analyzed using analysis of variance; categorical variables analyzed using Pearson chi-square test or Fisher exact test. P-values refer to comparisons between primary payer groups. Mean (standard deviation). Percents may not sum to 100 due to rounding and missing values.

Table 5

Outcome measures for patients undergoing total hip replacement according to primary payer group.

Characteristic	Medicare (%)	Medicaid (%)	Private Insurance (%)	Other (%)	Uninsured (%)	Overall (%)	P-value
In-hospital mortality							
No	164,495 (99.7)	10,150 (99.8)	110,093 (99.9)	8,015 (99.9)	2,301 (100.0)	295,054 (99.8)	<.0001
Yes	415 (0.3)	17 (0.2)	51 (0.0)	<11	<11		
Missing	17 (0.0)	<11	<11	<11			
Any complication	12,006 (7.3)	624 (6.1)	4,488 (4.1)	410 (5.1)	144 (6.3)	17,672 (6.0)	<.0001
Cardiovascular complications grouped variable	3,529 (2.1)	114 (1.1)	895 (0.8)	73 (0.9)	30 (1.3)	4,641 (1.6)	<.0001
Pulmonary complications grouped variable	4,613 (2.8)	281 (2.8)	2,023 (1.8)	206 (2.6)	57 (2.5)	7,180 (2.4)	<.0001
Infectious complications grouped variable	3,735 (2.3)	225 (2.2)	1,113 (1.0)	108 (1.3)	48 (2.1)	5,229 (1.8)	<.0001
Intraoperative complication grouped variable	1,078 (0.7)	71 (0.7)	475 (0.4)	36 (0.4)	17 (0.7)	1,677 (0.6)	<.0001
Gastrointestinal complication	988 (0.6)	40 (0.4)	420 (0.4)	32 (0.4)	<11		<.0001
90-Day Readmission**	18,444 (11.9)	1,320 (14.5)	7,461 (7.3)	676 (9.3)	174 (9.2)	28,075 (10.2)	
Length of stay: Median (Q1; Q3)	3 (3; 4)	4 (3; 5)	3 (3; 4)	3 (3; 4)	3 (3; 4)	3 (3; 4)	<.0001
Total charges in 2016 dollars: Median (Q1; Q3)	64,495 (48,110; 87,804)	66,561 (45,716; 92,108)	63,054 (47,780; 85,612)	68,924 (49,631; 93,172)	57,897 (39,947; 78,428)	64,080 (47,895; 87,280)	

Percents may not sum to 100 due to rounding and missing values.

Table 6

Risk-adjusted outcomes according to Primary Payer Status amongst patients undergoing total hip replacement.

Outcome	Medicare	Medicaid	Other	Uninsured	Private
Mortality	1.24 (0.78 – 1.98)	**2.25 (1.01 – 5.01)** *	1.32 (0.43 – 4.03)	0.68 (0.05 – 9.23)	1.0
30-Day Readmission	1.31 (1.22 – 1.40) ***	**1.63 (1.45 – 1.83)** ***	1.10 (0.94 – 1.28)	1.09 (0.80 – 1.48)	1.0
90-Day Readmission	1.28 (1.22 – 1.35) ***	**1.58 (1.44 – 1.73)** ***	1.13 (1.01 – 1.27) **	1.13 (0.90 – 1.40)	1.0
Any Complication	1.11 (1.04 – 1.18) ***	**1.26 (1.11 – 1.43)** ***	1.17 (1.02 – 1.35) **	1.27 (0.99 – 1.62)	1.0
Cardiovascular Complication	1.08 (0.94 – 1.23)	**1.37 (1.04 – 1.81)** **	1.09 (0.79 – 1.50)	1.43 (0.86 – 2.36)	1.0
Pulmonary Complication	1.09 (0.99 – 1.20)	1.13 (0.94 – 1.36)	1.28 (1.05 – 1.56) **	1.04 (0.71 – 1.53)	1.0
Infectious Complication	1.20 (1.06 – 1.36) ***	**1.66 (1.35 – 2.05)** ***	1.20 (0.92 – 1.57)	1.51 (0.99 – 2.31)	1.0
Gastrointestinal Complication	1.06 (0.86 – 1.31)	1.02 (0.65 – 1.60)	0.88 (0.54 – 1.44)	0.87 (0.34 – 2.19)	1.0
Intraoperative Complication	1.20 (0.98 – 1.47)	1.12 (0.78 – 1.61)	0.90 (0.57 – 1.42)	1.52 (0.77 – 3.01)	1.0
Length of Stay	1.04 (1.03 – 1.04) ***	**1.18 (1.18 – 1.19)** ***	1.09 (1.08 – 1.10) ***	1.09 (1.08 – 1.11) ***	1.0

*** denotes where p<=0.001,

** p<=0.005,

* p<=0.01. 99% CI.

Bold refers to statistically significant outcomes where Medicaid had worse outcomes as compared to Private Insurance (versus other Payment types compared to Private Insurance).