Hospital safety net burden is associated with increased inpatient mortality and postoperative morbidity after total hip arthroplasty: a retrospective multistate review, 2007–2014

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ABSTRACT

Background Total hip arthroplasty (THA) is one of the most widely performed surgical procedures in the USA. Safety net hospitals, defined as hospitals with a high proportion of cases billed to Medicaid or without insurance, deliver a significant portion of their care to vulnerable populations, but little is known about the effects of a hospital's safety net burden and its role in healthcare disparities and outcomes following THA. We quantified safety net burden and examined its impact on in-hospital mortality, complications and length of stay (LOS) in patients who underwent THA.

Methods We analyzed 500 189 patient discharge records for inpatient primary THA using data from the Healthcare Cost and Utilization Project's State Inpatient Databases for California, Florida, New York, Maryland and Kentucky from 2007 to 2014. We compared patient demographics, present-on-admission comorbidities and hospital characteristics by hospital safety net burden status. We estimated mixed-effect generalized linear models to assess hospital safety burden status' effect on in-hospital mortality, patient complications and LOS.

Results Patients undergoing THA at a hospital with a high or medium safety net burden were 38% and 30% more likely, respectively, to die in-hospital compared with those in a low safety net burden hospital (high adjusted OR: 1.38, 95% CI 1.10 to 1.73; medium adjusted OR: 1.30, 95% CI 1.07 to 1.57). Compared with patients treated in hospitals with a low safety net burden, patients treated in high safety net hospitals were more likely to develop a postoperative complication (adjusted OR: 1.11, 95% CI 1.00 to 1.24) and require a longer LOS (adjusted IRR: 1.06, 95% CI 1.05, 1.07).

Conclusions Our study supports our hypothesis that patients who underwent THA at hospitals with higher safety net burden have poorer outcomes than patients at hospitals with lower safety net burden.

INTRODUCTION

Total hip arthroplasty (THA) for the management of severe arthritic disease improves health-related quality of life.[1] In the USA, yearly, more than 400 000 surgeries were performed in 2012[2 3]; 572 000 are estimated to be performed by 2030.[4 5] Nevertheless, the procedure is associated with 30-day mortality risk of 0.35% and a complication rate of about 4.9%.[6]

Evidence supports the association between THA outcomes and multifactorial patient-level, provider-level and hospital-level racial and socio-economic disparities.[7–16] Hospital safety net burden is defined as the proportion of cases at an individual hospital with the primary insurance payer being Medicaid or uninsured; safety net hospitals operate with a mandate or adopted mission to deliver care to patients regardless of their ability to pay.[17 18] Research shows higher rates of mortality, hospital-acquired infection, perioperative complications and poorer markers of surgical quality (timeliness, patient centeredness and equity of treatment) at high safety net burden hospitals.[19–23] Poorer outcomes were initially attributed to selection bias, but analyses adjusting for patient and hospital characteristics have highlighted intrinsic contributing hospital qualities.[20 21] Few national studies have examined the association between hospital safety net burden and postoperative outcomes following THA.[21 22]

We aimed to conduct a multistate retrospective analysis utilizing the State Inpatient Databases (SID; 2007–2014) to examine differences in postoperative outcomes among patients who underwent THA at hospitals with differing proportion of safety net burden (proportion of all cases at a hospital with the primary payer listed as Medicaid or uninsured)[21 23]; hospital-specific proportions are then placed into appropriate ordinal categories for analysis. We considered hospital safety net burden as a hospital-level social determinant of health that would increase the likelihood of negative perioperative outcomes; accordingly, we anticipated a significant difference in in-hospital mortality, postoperative outcomes and length of stay (LOS) after THA in patients receiving care at varying levels of safety net burden hospitals.

METHODS

Study database and population

We queried retrospective inpatient hospital discharge records from adults (age ≥18 years) who underwent THA surgery using 2007–2014 data from California, Florida, New York, Maryland and Kentucky from the SID, Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality.[24] California data included only cases from 2007 to 2011. The SID contains all payer inpatient data from non-federal, non-psychiatric hospitals; validity and internal consistency of the SID data set are verified by

quality control measures established by HCUP.[24] Records were abstracted using *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) procedure code 81.51, representing primary THA surgeries only.

Inclusion criteria for our study included all patients ≥18 years who underwent THA surgery and who did not meet the exclusion criteria. Exclusion criteria included missing demographic data (age, sex or primary insurance status). For each model, additional cases were dropped from multivariable analyses if they included any missing data on included independent or dependent variables (complete case analysis).

Data are coded so that each inpatient hospital admission corresponds to an individual record. Variables abstracted for each admission include demographic information, ICD-9-CM diagnosis and procedure codes, hospital LOS, patient insurance type (or expected payer), admission and discharge dates and discharge disposition. The SID contains present-on-admission (POA) indicators for each diagnosis that facilitates delineating pre-existing medical comorbidities from perioperative complications.

Patients were categorized by expected insurance 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, private health maintenance organizations, and preferred provider organizations). POA comorbid medical conditions were selected from the Elixhauser comorbidity index.[25] Additionally, patients were categorized into quartiles of median state household income (herein referred to as median income) by their home ZIP code and by recorded race/ethnicity (white, black, Hispanic, other or missing).

Hospitals were cohorted by the proportion of inpatient cases (irrespective of procedure) billed to Medicaid or identified as unpaid (ie, labeled as uninsured), herein referred to as safety net burden.[21] We chose to not use a definition of safety net burden based on the percentage of THA patients with Medicaid/uninsured payer status by hospital due to possible scenarios in which a hospital has a high representation of Medicaid/uninsured in its THA payer population but low representation across all other procedures.[26–28] Hospitals in our population were thus stratified into tertiles based on the distribution of their proportion of safety net cases across all procedures; these were characterized as low, medium or high.[26–28] Low safety net burden hospitals had 0%–16.83% of cases with Medicaid or uninsured listed as primary payer, medium safety net burden hospitals had 16.84%–30.45% and high safety net burden hospitals had ≥30.46% of their cases identified as being paid by Medicaid or uninsured. Quartiles were created for hospital-specific surgical volumes for THA.

Primary outcome
The primary outcome of our study was in-hospital mortality.

Secondary outcomes
Secondary outcomes included all-cause postoperative complications, individual complication group variables and hospital LOS to examine the effect of hospital safety net burden as a social determinant of health. Postoperative complication groups were: cardiovascular, pulmonary, infectious and intraoperative; all complications were indicated as not present on admission in the database.[7]

Statistical analysis
Demographic characteristics and POA comorbidities were compared for all patients who underwent THA by hospital safety net burden status. Unadjusted rates of in-hospital mortality, postoperative complications and LOS for all patients were compared by hospital safety net burden categories. Continuous variables were compared using analysis of variance, and categorical variables were compared using the χ^2 test. Non-parametric equivalents were used for variables that violated assumptions of normality.

To examine the effect of hospital safety net burden status on postoperative outcomes, while adjusting for demographic factors, comorbidities and other potential confounders, mixed-effects general linear models were fit to the data; accordingly, adjusted ORs for dichotomous outcomes and adjusted incidence rate ratios (aIRR; the ratio of the average LOS from one group vs another) for count outcomes with 95% CIs are reported. Random components in mixed-effects models take into account the fact that clustering occurs when individual hospitals contribute repeated observations to the overall analyses. We developed separate models for our binary outcomes of interest: in-hospital mortality and a composite outcome of postoperative complications, which included any cardiovascular, pulmonary, infectious and intraoperative complication.[7] We additionally modeled each of these complication types individually. We developed an additional model for the count outcome of LOS, in which we specified a Poisson distribution and log link, based on a visual inspection of a histogram of the outcome measure. To account for a potential violation in our assumption regarding the distribution of the measure of LOS, we report the results from the model with robust SEs.

In an effort to take into account potential variables confounding the relationship between hospital safety net burden and our outcomes, the multivariable models included hospital and patient demographic characteristics and comorbidities with bivariate testing results at a p≤0.05 significance level: primary insurance payer (Medicare, Medicaid, private insurance, uninsured and other types of insurance); race/ethnicity (white, black, Hispanic and other); quartile of median income of patient's ZIP code of residence within their respective state; sex; age (as a linear term); Elixhauser comorbidity measures[25]; year of procedure; quartile of hospital THA procedure volume; and hospital state. Individual hospital was included as a level-two covariate (random effect).

To assess potential effect measure modification, we fit models for all outcomes containing interaction terms between the three-category measure of safety net burden and, separately, primary insurance payer, race/ethnicity and median income quartile. We conducted likelihood ratio tests to assess model fit between the original model without interaction terms and the interaction model. For any model pair with likelihood ratio test p<0.05, we conducted the Wald test to compare the significant interaction term variables against their main effects. In models where the likelihood ratio test and Wald statistics indicated that the model with interaction terms was superior to the original model, we calculated a linear combination of coefficients for significant interaction effects to derive ORs or incidence rate ratios.

We subsequently fit a series of additional exploratory stratified multivariable models by primary insurance payer, race/ethnicity, median income quartile, hospital state, for cases with diagnoses of a hip fracture (ICD-9-CM: 820.0–820.9) and for cases with a diagnosis of osteoarthritis (ICD-9-CM: 715.x) for our primary and all secondary outcomes. Results reported from stratified
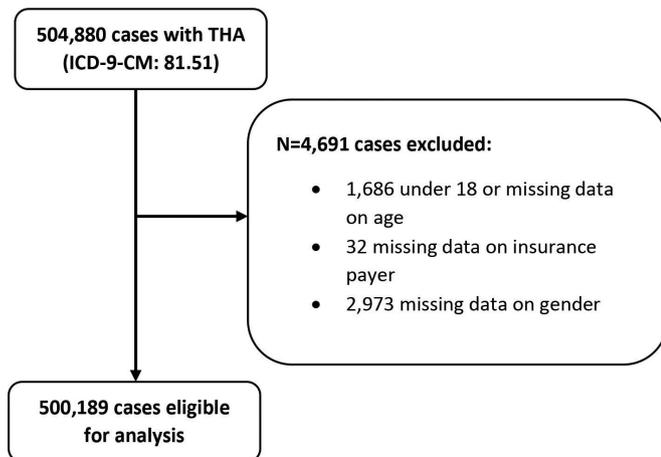
Figure 1 STROBE figure of included THA patients. STROBE, Strengthening the Reporting of Observational Studies in Epidemiology; THA, total hip arthroplasty.

models are limited because of limitations in statistical power; they represent trends in findings as corroborative evidence.

To validate our decision to classify safety net burden status in tertiles in our main analyses, we additionally fit multivariable models for each outcome with safety net burden status in quartiles: hospitals in the lowest quartile had 0%–12.66% of their cases paid by Medicaid or uninsured; 12.67%–23.05% in the second quartile; 23.06%–35.72% in the third quartile; and ≥35.73% in the top quartile.[23][29]

Finally, we conducted an additional multivariable exploratory analysis of cases from New York only to assess any effect of hospital safety net burden on the type of anesthesia received for THA: general or regional. We analyzed data on anesthesia type only from New York because the anesthesia type measure was not available in other states. Model assumptions of normality and linearity were assessed graphically and statistically. P values are two sided with statistical significance evaluated at <0.05 alpha level. Statistical tests and analysis were performed using SAS V.9.4 and Stata SE VV.15.

RESULTS
Bivariate results
The total number of patients with THA in the database was 504 880. After dropping cases with missing data on age (or

<18 years old), primary insurance payer or gender, the analysis sample size was 500 189 (0.9% reduction, figure 1). Hospital category descriptive statistics are found in online supplementary table 1 and table 1 (patient-level and hospital-level factors, respectively).

A total of 89 391 cases (17.9%) were performed at high, 209 942 (42.0%) at medium and 200 856 (40.2%) at low burden hospitals. As expected, high burden hospitals had a higher proportion of Medicaid and uninsured patients. Additionally, they treated a larger percentage of blacks and Hispanics, patients with residency in the poorest neighborhoods and the smallest proportion of highest hospital surgical volume procedures. There was no discernable trend between hospital categories and overall patient comorbidities. Frequency of outcome variables by hospital safety net burden are presented in table 2.

Multivariable results
Primary outcome: in-hospital mortality
Controlling for the aforementioned potential confounders, patients having a THA at high (aOR: 1.38, 95% CI 1.10 to 1.73, p<0.01) or medium burden hospitals (aOR: 1.30, 95% CI 1.07, 1.57, p<0.01) were more likely to die in-hospital compared with those in a low burden hospital (table 2; complete case analysis, N=500 110) (figure 2, table 2). Results were similar in sensitivity models that were fit with safety net burden split into quartiles (online supplementary table 2).

We found that interaction models were not a better fit than our main models for inpatient mortality. Due to small sample sizes and insufficient variation on the outcome measure, post hoc stratified subgroup analyses were only able to be conducted in select populations, mostly confirming our initial hypothesis/findings. We caution interpretation of these results reporting them only as trend/corroborating evidence. Inpatient mortality was statistically different in populations of Medicare (high burden aOR: 1.45, 95% CI 1.13 to 1.86, p<0.01; medium burden aOR: 1.33, 95% CI 1.08 to 1.64, p<0.01); white (high burden aOR: 1.31, 95% CI 1.01 to 1.70, p<0.05; medium burden aOR: 1.33, 95% CI 1.09 to 1.64, p<0.01); third quartile of median income (aOR: 1.75, 95% CI 1.16 to 2.63, p<0.01); and in Florida patients (high burden aOR: 2.07, 95% CI 1.36, to 3.16, p<0.001; medium burden aOR 1.85, 95% CI 1.29 to 2.66, p<0.001) (unpublished data). The significant effect was not observed in other social determinant groups, nor in subdiagnosis populations; these insignificant

Table 1 Hospital characteristics for patients undergoing THA according to hospital safety net burden category

Characteristic	Overall, n (%)	Low burden, n (%)	Medium burden, n (%)	High burden, n (%)	P value
Hospital volume					<0.0001
First quartile	125 767 (25.1)	35 778 (17.8)	55 816 (26.6)	34 173 (38.2)	
Second quartile	124 720 (24.9)	43 196 (21.5)	54 040 (25.7)	27 484 (30.7)	
Third quartile	121 942 (24.4)	49 791 (24.8)	57 476 (27.4)	14 675 (16.4)	
Fourth quartile	127 760 (25.5)	72 091 (35.9)	42 610 (20.3)	13 059 (14.6)	
CBSA designation					<0.0001
Non-CBSA	16 492 (3.3)	3006 (1.5)	10 160 (4.8)	3326 (3.7)	
Micropolitan statistical Area	28 745 (5.7)	5328 (2.7)	18 298 (8.7)	5119 (5.7)	
Metropolitan statistical Area	452 520 (90.5)	191 558 (95.4)	180 685 (86.1)	80 277 (89.8)	
Missing	2432 (0.5)	964 (0.5)	799 (0.4)	669 (0.7)	

P values refer to comparisons between hospital burden categories.
Categorical variables analyzed using the χ^2 test.
Per cents may not sum to 100 due to rounding and missing values.
CBSA, core-based statistical area.

Table 2 Frequency and risk-adjusted odds of outcome measures for patients undergoing THA according to hospital safety net burden category

Outcome	No. (%)	OR or IRR (95% CI)
In-hospital mortality		
Low burden	241 (0.1)	1.00 (reference)
Medium burden	367 (0.2)	1.30** (1.07 to 1.57)
High burden	783 (0.2)	1.38** (1.10 to 1.73)
Any complication		
Low burden	10 475 (5.2)	1.00 (reference)
Medium burden	12 387 (5.9)	1.00 (0.91 to 1.11)
High burden	28 782 (5.8)	1.11* (1.00 to 1.24)
Cardiovascular complication		
Low burden	2815 (1.4)	1.00 (reference)
Medium burden	3082 (1.5)	0.99 (0.89 to 1.09)
High burden	7302 (1.5)	1.15* (1.02 to 1.29)
Pulmonary complication		
Low burden	4571 (2.3)	1.00 (reference)
Medium burden	5331 (2.5)	1.04 (0.92 to 1.18)
High burden	12 579 (2.5)	1.13 (0.99 to 1.30)
Infectious complication		
Low burden	2812 (1.4)	1.00 (reference)
Medium burden	3599 (1.7)	1.07 (0.94 to 1.22)
High burden	8066 (1.6)	1.24** (1.07 to 1.43)
Intraoperative complication		
Low burden	845 (0.4)	1.00 (reference)
Medium burden	1081 (0.5)	1.03 (0.83 to 1.28)
High burden	2444 (0.5)	1.11 (0.87 to 1.42)
Length of stay		
Low burden	3 (3; 4)†	1.00‡ (reference)
Medium burden	3 (3; 4)†	1.01*‡ (1.00 to 1.01)
High burden	3 (3; 4)†	1.06***‡‡ (1.05 to 1.07)

Per cents may not sum to 100 due to rounding and missing values. All numbers reported are n (%), ORs (95% CI) unless noted otherwise.
Models were clustered on hospital as a level-two covariate (random effect) and were adjusted for primary insurance payer, race/ethnicity, quartile of median income, sex, age, select Elixhauser comorbidity measures, year of procedure, quartile of hospital THA procedure volume and hospital state.
*P<0.05, **P<0.01, ***p<0.001.
†Median (IQR).
‡Incidence rate ratio (IRR), 95% CI.
THA, total hip arthroplasty.

findings were likely secondary to insufficient statistical power and followed our general findings.

Postoperative complications

THA patients at high as compared with low burden hospitals were more likely to have any postoperative complication (aOR: 1.11, 95% CI 1.00 to 1.24, p<0.05) (table 2; complete case analysis, N=500 188). When complication groupings were individually modeled as outcomes, patients treated at high burden hospitals had increased aOR of cardiovascular and infectious complications. Sensitivity models with hospital safety net burden split into quartile is shown in online supplementary table 2.

Models including interaction terms of safety net burden and primary insurance payer provided a better fit than main models for any complication and cardiovascular complications (table 3).

In stratified subgroup analyses, only in select populations did high compared with low burden status significantly increase the aOR of postoperative complication (unpublished data): Medicare (aOR: 1.18, 95% CI 1.06 to 1.32, p<0.01,); white (aOR:
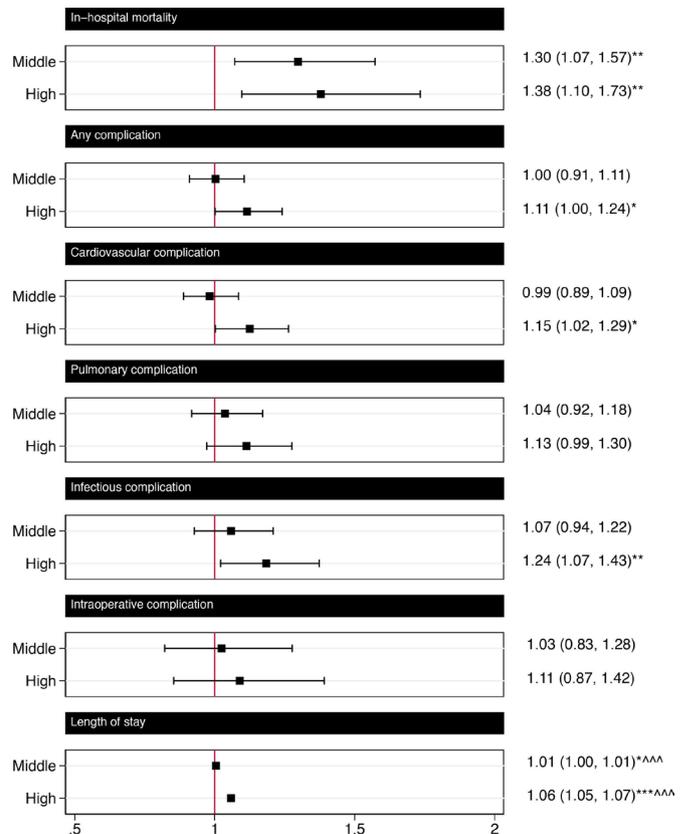

Figure 2 Adjusted odds of outcomes according to hospital safety net burden status reference category: low hospital safety net burden adjusted ORs, incidence rate ratios (95% CI). *P<0.05, **p<0.01, ***p<0.001. ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification; THA, total hip arthroplasty.

1.15, 95% CI 1.02 to 1.29, p<0.05); in the lowest quartile of median income (aOR: 1.18, 95% CI 1.01 to 1.38, p<0.05); and in patients treated in Kentucky hospitals (aOR: 1.78, 95% CI 1.03 to 3.06, p<0.05).

Length of stay

High burden THA patients had longer LOS than low burden hospital THA patients (95% CI 1.05 to 1.07, p<0.001) (table 2; complete case analysis, N=500 188); the effect was similar in sensitivity analysis with safety net burden split into quartiles (online supplementary table 2).

We were unable to conduct likelihood ratio tests with outcome LOS due to its estimation with robust SEs. Models of LOS had significant interaction effects between safety net burden hospital status and insurance status, race and median income (table 3).

Little evidence of effect modification as determined by stratified models existed by social determinants of health, THA indication or state in LOS models, and in most subpopulations, high hospital burden had significantly longer LOS. Stratified models revealed that the effect of safety net burden on LOS was significant for patients treated in medium burden hospitals for second (aIRR: 1.04, 95% CI 1.01 to 1.07, p<0.05) and fourth (aIRR: 1.04, 95% CI 1.01 to 1.08, p<0.05) quartile median income patients, as compared with first quartile median income, and hip fracture patients (aIRR: 1.05, 95% CI 1.00 to 1.10, p<0.05) (unpublished data).

Table 3 Interaction effects

Outcome	Significant (p<0.05) interaction term with hospital safety net burden	Category of hospital safety net burden	Reference category	Linear combination OR (95% CI)
Any complication	Medicaid patients	High safety net burden	Private insurance, low safety net burden	1.33 (1.15 to 1.54)***
Cardiovascular complication	Other insurance	High safety net burden	Private insurance, low safety net burden	0.73 (0.45 to 1.17)†
LOS	Medicaid patients	Medium safety net burden	Private insurance, low safety net burden	1.22 (1.19 to 1.24)***‡
LOS	Medicare	High safety net burden	Private insurance, low safety net burden	1.12 (1.11 to 1.13)***‡
LOS	Other insurance	High safety net burden	Private insurance, low safety net burden	1.29 (1.26 to 1.33)***‡
LOS	Uninsured	High safety net burden	Private insurance, low safety net burden	1.48 (1.34 to 1.64)***‡
LOS	Hispanic	Medium safety net burden	White, low safety net burden	1.10 (1.08 to 1.11)***‡
LOS	Missing (race)	Medium safety net burden	White, low safety net burden	1.09 (1.07 to 1.11)***‡
LOS	Other race	High safety net burden	White, low safety net burden	1.24 (1.19 to 1.30)***‡
LOS	Missing (race)	High safety net burden	White, low safety net burden	1.19 (1.15 to 1.22)***‡
LOS	Fourth quartile median income	High safety net burden	First quartile, low safety net burden	1.04 (1.02 to 1.05)***‡
LOS	Missing (income)	High safety net burden	First quartile, low safety net burden	1.29 (1.21 to 1.37)***‡

*P<0.05, **p<0.01, ***p<0.001.

†P=0.19. Though this model with interaction terms was shown to be a significantly better fit than the main model, its linear combination of coefficeints was not significant at alpha=0.05.

‡Incidence rate ratio (IRR), 95% CI.

Anesthesia type

In exploratory analysis of New York data (N=112 217), patients treated at high and medium, as compared separately to low burden hospitals, were more likely to undergo THA with general rather than regional anesthesia (high burden aOR: 2.59, 95% CI 2.44 to 2.74, p<0.001; medium burden aOR: 3.78, 95% CI 3.68 to 3.90, p<0.001, unpublished data).

DISCUSSION

Our multistate analysis shows patients undergoing THA in high safety net burden hospitals experience higher unadjusted rates and adjusted odds of in-patient mortality, overall postoperative complications and LOS; additionally, in exploratory analysis of New York only, patients at high burden hospitals were more likely to undergo THA under general anesthesia. Our multivariable models were adjusted for patient-centric (demographics, Elixhauser comorbidities and surgical diagnosis),[25] surgical-centric (state and year) and hospital-centric factors (procedural volume and random effects clustering to account for individual hospital characteristics/practice patterns).[30] The constellation and consistency of our findings for clinical pathway measures and through interaction, stratified and sensitivity analysis allowed us to better explain associations between safety net burden and THA outcomes. We acknowledge that our stratified models were exploratory and mostly underpowered to show statistical significance, allowing for trend analysis and collaborative findings only.

US healthcare policy is in flux and of particular concern is the impact on vulnerable populations. Xu et al[7] showed that Medicaid (as compared with private insurance) THA patients had higher odds of postoperative in-hospital mortality, increased complications, LOS and readmissions. White et al[15] showed that THA patients with Medicaid/Medicare, who are blacks, live in poorer neighborhoods and are treated at hospitals with a low surgical volume, have higher odds of readmission. Elsharydah et al found that a propensity matched cohort of black patients had higher rates of 30 day complications for lower extremity arthroplasty.[10]

Several studies have found that hospital factors such as safety net burden impact surgical outcomes.[31–35] Hoehn et al[21] reported that high safety net burden hospitals had higher post-surgical mortality and LOS; subgroup analysis of THA patients found increased costs with procedures performed at high burden hospitals but no mortality or readmissions difference. Jergesen and Yi[36] examined single surgeon lower extremity arthroplasties and found that early complications and reoperations were more common at a safety net hospital than a university medical center. To the best of our knowledge, our findings are the most recent comprehensive study on safety net burden and THA postoperative outcomes, thus addressing an important gap in the literature.

Safety net hospitals face several financial disadvantages as they are mandated to care for all patients regardless of reimbursement. Hospitals without mandates are able to streamline services improving quality, efficiency and cost-effectiveness, usually though reducing or abolishing safety net services and specialization in profitable clinical services.[37 38] Resultantly, safety net hospitals have limited flexibility to tackle financial challenges, and research has shown that poor hospital financial health contributes to worse patient outcomes, including mortality and medical error rate.[39–41] Reimbursement policies such as the 2016 Comprehensive Care for Joint Replacement Model[42] and the Hospital Readmissions Reduction Program make financial penalties more likely to affect safety net hospitals.[43 44] Disproportionate share hospital payments, intended to offset the cost of uncompensated care, will decrease with reductions totaling $35.1 billion by 2024.[45] Policy makers should re-examine reimbursement policies and financial penalties that disproportionately affect safety net hospitals.[20]

While resource limitation is a driving factor for quality disparities in safety net hospitals, intrinsic hospital characteristics in organizational culture, processes of care and resource utilization also contribute. High burden hospitals performed worse in measures outlined by the Surgical Care Improvement Project, including antibiotic and venous thromboembolism prophylaxis, perioperative beta-blocker use and urinary catheter management.[21] Safety net hospitals were found deficient in emergency department efficiency and throughput markers[21] suggesting systemic deficiencies in staffing and quality improvement budgets.[20] Failure to rescue, the mortality rate after postoperative complications, was increased in high burden hospitals, even after adjustment for advanced technology and clinical resources.[46]

Evidence suggests that anesthesiologists influence disparities.[47] In a survey of safety net hospitals, approximately 20% lacked anesthesia preoperative clinics and pain management protocols.[48] Black patients and patients Medicaid or who are uninsured are less likely to receive neuraxial or regional anesthesia for lower extremity arthroplasty.[49] Hospital-level and anesthesiologist practice attributes nearly 40% of the variation in neuraxial anesthesia use in hip fracture surgery.[50] Hospital-level neuraxial anesthesia use alone was associated with better hip surgery outcomes independent of individual patient anesthesia and confounders. Hospitals that use more than 20%–25% neuraxial anesthesia for hip fracture surgery have improved survival[51]; increased hospital neuraxial anesthesia use was associated with lower costs for lower extremity replacements.[52] Our post hoc exploratory analysis on THA anesthesia type by hospital safety net burden found that patients treated at high and medium burden hospitals were more likely to undergo surgery with general than regional anesthesia.

Solutions to these disparities will be complex and multifaceted. Studies advocate either for increased funding resources or redistributing patients away from safety net hospitals.[53] Evidence-based interventions and strict adherence to national guidelines to reduce unnecessary variation in care could potentially improve disparities.[46 54 55] Fast-track surgery or enhanced recovery pathways are being applied as a way to improve outcomes and reduce costs through standarization.[54 56] Regional and multimodal anesthesia-analgesic regimens are recognized as important contributors to improving hospital LOS, time to ambulation and postoperative complications.[56–59] Enhanced recovery pathways, however, can face implementation headwinds requiring organizational culture changes and provider and patient buy-in. While safety net hospitals encounter multiple unique barriers (limited resources, consistent staffing and patient compliance), a survey of providers and patients at one hospital identified strong support for enhanced recovery pathways.[60] Appropriate operative use of hospital benchmarking through reproducible, optimal, objective and universal patient measures can also drive surgical outcome improvement through adoption of best practices.[61] Establishing a national agenda for surgical disparities research will also help to find effective and innovative approaches to address disparities.[62] National anesthesia organizations, such as the American Society of Regional Anesthesia and Pain Medicine can play a huge role in mobilizing its membership to accomplish this goal; likewise relevant clinical journals can make it a priority to publish and promote such findings to raise awareness.

Our study has several limitations. Administrative datasets, such as HCUP-SID, are reliant on accuracy and completeness of clinical coding and are subject to misclassification or missing data.[7 24] HCUP-SID does not include intraoperative or quantitative clinical data, limiting our ability to classify severity of patient comorbidities beyond qualification of presence as captured by Elixhauser comorbidity measures.[25] We were only able to examine inpatient outcomes; we were unable to analyze non-hospital setting outcomes, potentially underestimating adverse outcomes. HCUP-SID does not contain data on hospital type nor the surgical team composition (ie, teaching hospital and presence of trainees), which has been shown to affect surgical outcomes.[24 63 64] However, SID does contain hospital identifiers and were able to cluster by hospital in our regression models. Nevertheless, the potential for unmeasured (residual) confounding remains a major limitation to the validity of our study's statistical analysis.

Our study has numerous strengths. HCUP data validation ensures both internal and external consistency and accuracy.[24] Our analysis used data from five diverse states in terms of demographics, size and geography; these states represent approximately 28% of the US population.[24 65] To correct for the potential that the included states are not representative of the national population and to identify any interstate differences, we performed additional analyses of our primary and secondary outcomes in stratified models by individual state. Data were also abstracted from eight consecutive years, resulting in a study cohort of more than 500 000 patients who underwent THA.[66] The wide range of states and years included from an all payer dataset contributes to the broad generalizability and validity of our results across hospitals and all insurance payer types; however, we are unable to say that our findings reflect or are applicable to individual institutions, hospitals or practitioners. The large patient population included in our analysis allowed us to statistically adjust for a considerable amount of patient-centric, procedure-centric and hospital-centric confounders, reducing potential bias. Finally, consistency of our results among various points of the clinical pathway highlights the robustness of our findings.

CONCLUSIONS

THA patients at high safety net burden hospitals had higher unadjusted rates and risk-adjusted odds of inpatient mortality as compared with THA patients at low burden hospitals. We found similar results for our two secondary outcomes: postoperative complications and LOS (and for our exploratory analysis-administered anesthesia type). Safety net hospitals play an important role in our healthcare system, yet multiple challenges threaten their existence. Our results highlight significant hospital-level disparities in the healthcare delivered and present considerable impetus for policy measures that can address these inequalities.

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