The American Journal of Surgery 220 (2020) 525–531

Contents lists available at ScienceDirect

The American Journal of Surgery

journal homepage: www.americanjournalofsurgery.com

Examining healthcare inequities relative to United States safety net hospitals

Anghela Z. Paredes [a], J. Madison Hyer [a], Adrian Diaz [a], Diamantis I. Tsilimigras [a], Timothy M. Pawlik [b, *]

[a] Department of Surgery, Division of Surgical Oncology, The Ohio State University Wexner Medical Center and James Comprehensive Cancer Center, 395 W. 12th Ave., Suite 670, Columbus, OH, 43210, USA

[b] Department of Surgery, Division of Surgical Oncology, The Urban Meyer III and Shelley Meyer Chair for Cancer Research, The Ohio State University Wexner Medical Center, 395 W. 12th Ave., Suite 670, Columbus, OH, 43210, USA

ARTICLE INFO

Article history:
Received 22 August 2019
Received in revised form
22 January 2020
Accepted 22 January 2020

Keywords:
Safety net burden
Disparities
Inequity

ABSTRACT

Introduction: The impact of safety net (SN) hospitals relative to racial and healthcare disparities remains largely unknown.

Methods: Using the Nationwide Inpatient Sample, adults undergoing coronary artery bypass grafting, colectomy, or total hip arthroplasty were identified. Multivariable regression analysis was performed to determine association between SN burden and outcomes. Within each SN burden tier, the association between race/ethnic group and outcomes was defined.

Results: Overall 865,648 patients were identified. After adjustment for potential confounders, patients operated at the highest SN burden hospitals had increased odds of complications (OR 1.14, 95%CI 1.10–1.18), death (OR 1.41, 95%CI 1.31–1.52), FTR (OR 1.36, 95%CI 1.25–1.47) and a never event (OR 1.57, 95%CI 1.47–1.68). Irrespective of hospital SN burden, racial minorities had greater odds of a complication, and prolonged LOS compared to whites ($p < 0.05$).

Conclusion: While overall degree of safety net burden was associated with worse overall outcomes, SN hospitals did not mitigate racial disparities experienced by minority patients.

Introduction

The racial/ethnic composition of the United States has dramatically changed over the past several decades.[1] In addition, the Pew Research Center predicts that by 2065 no racial or ethnic group will be a majority.[1] Despite the growing population of racial/ethnic minorities, navigating the health-care system for this group of patients remains plagued by multiple hurdles.[2,3] In fact, even after the enactment of the Affordable Care Act (ACA), health-care access and outcomes remain inequitable for minorities especially among those individuals who speak a language other than English or who are economically impoverished.[4–7] As such, several organizations including the Institute of Medicine,[8] Centers for Disease Control and Prevention,[9] National Institutes of Health and the American College of Surgeons[10] have increased their efforts to identify health disparities and support research to identify solutions to ensure equitable healthcare for all individuals. Minorities remain, however, underrepresented in cancer clinical trials,[11] and are less likely to undergo minimally invasive surgical modalities (i.e. robotic and laparoscopic surgery)[12–15] and, as such, are less likely to benefit from certain advancements in science and medicine.

One promising effort to ensure healthcare access to all individuals has been through the financial support of safety net (SN) hospitals. These hospitals have been designed to provide healthcare for all individuals regardless of insurance status. In light of the repeal of the individual insurance coverage mandate penalty, researchers have forecasted an increase in the number of uninsured individuals, which may in turn worsen current racial/ethnic health disparities. To date, whether SN hospitals can mitigate healthcare disparities among surgical patients has not been well examined. As such, the present study sought to define the impact of hospital SN status on outcomes among individuals undergoing common surgical procedures such as colectomy, coronary artery bypass grafting

* Corresponding author. Department of Surgery The Urban Meyer III and Shelley Meyer Chair for Cancer Research The Ohio State University, Wexner Medical Center 395 W. 12th Ave., Suite 670, Columbus, OH, 43210, USA.
E-mail address: tim.pawlik@osumc.edu (T.M. Pawlik).

https://doi.org/10.1016/j.amjsurg.2020.01.044

(CABG), or total hip arthroplasty (THA). In particular, we sought to assess the association of self-identification as a racial/ethnic minority on perioperative outcomes with a specific focus on defining whether minority status altered outcomes relative to hospital SN burden.

Methods

Data source and study population

The National Inpatient Sample (NIS) database from 2004 to 2014, developed by the Healthcare Cost and Utilization Project, was used to identify patients 18 years of age or older who underwent general surgical procedures (colectomy, CABG, THA) using Internal Classification of diseases, Ninth Edition, Clinical Modification (ICD-9-CM) Procedure codes. Similar to previous studies, the operative case mix was selected to sample a generalizable surgical cohort with substantial associated costs across three different specialties.[16,17] The NIS database approximates a 20% stratified samples of all discharges, irrespective of payer source across the United States.[18]

Patients included in the study cohort had an elective or emergent hospital admission during which one of the previously listed procedures was performed. Individuals younger than 18 years of age were excluded. For the purposes of this study, only individuals whose race/ethnicity was known were included in the analytic cohort. Patients with unknown payer source were excluded. In order to limit sampling bias, only hospitals that annually performed at least 50 of the surgeries of interest were included in the final cohort.

Variables

As previously described, risk of mortality and severity of illness was determined using the All Patient Refined Diagnosis Related Group.[19] Additional variables extracted from the dataset included age, primary payer source and income quartile. Hospital characteristics abstracted included teaching status, number of beds as a proxy for hospital size, and region. Using previously reported ICD-9 diagnosis and procedure codes, incidence of a complication and a never event were determined.[20,21] A never event is described by the Centers for Medicare and Medicaid Services (CMS) as "serious and costly errors in the provision of health care services that should never happen.[22]" Specifically, never events include catheter based urinary tract infection, air emboli, blood incompatibility, stage 3 or 4 pressure ulcers, falls, vascular catheter infections, complications of poor glucose control, retained foreign bodies, and wrong site surgery.[22,23] Expenditures per admission were adjusted for inflation, cost-to-charge ratio and wage index of each respective hospital. Mortality was defined as a death occurring during index hospitalization following surgery. Failure-to-rescue (FTR) was defined as a death in an individual who suffered a complication post-operatively.[24]

For each hospital that met inclusion criteria, SN burden was calculated based on previously published work.[25] Briefly, SN burden was equal to the division of hospital admissions for individuals who had Medicaid insurance, were uninsured, or were classified as "no charge" divided by the total number of admissions for each respective hospital. Safety net burden was then stratified into four tiers using a bisecting K-means clustering method with bin sorting by median to compute the cluster seed. The K-means clustering method groups data into more homogenous groups than traditional quartile groupings that assumes a normal distribution.[26]

Statistical analysis

The cohort was stratified into four groups based on hospital SN burden tier (lowest, low, high, highest). Demographics, clinical characteristics, expenditures, outcomes (complications, mortality, never event, FTR, extended LOS) were compared across SN burden categories. Categorical variables were presented as frequencies and percentages, whereas continuous variables were presented as medians and interquartile ranges (IQR). Chi square test was used to compare categorical variables whereas continuous variables were compared using Kruskal-Wallis one-way analysis of variance. Multivariable logistic regression was utilized to characterize the association among SN burden tier and outcomes of interest while adjusting for all relevant clinical and demographic variables. To determine the possible differential effect of SN burden on the association of race and outcomes of interest, logistic regression analyses were repeated stratifying by SN burden tier. Statistical significance was assessed at $\alpha = 0.05$. Analysis was completed using SAS v9.4.

Results

Patient and hospital characteristics

A total of 865,648 individuals who met inclusion criteria were identified across 3090 hospitals. More than one-third of patients underwent a THA (n = 333,639, 38.5%), whereas 33% (n = 283,606) and 29% (n = 248,403) underwent a colectomy or CABG, respectively (Table 1). Overall, median patient age was 64 years (IQR: 55–71) with the majority of individuals being male (n = 468,079, 54.1%) and white (n = 704,042, 81.3%). The median comorbidity burden score was 2 (IQR 1–4) and a subset of patients were categorized as having moderate loss of function (n = 359,296, 41.5%) with a minor likelihood of death (n = 472,611, 54.6%). Most hospitals were small (n = 1,127, 36.5%) and located in the south (n = 1,165, 37.7%) (Table 2). At roughly one-half of the hospitals, at least one in four patients was insured through Medicaid, self-pay or "no charge" (median SN proportion: 24.2, IQR 16.2–32.8).

Overall, median LOS was 5 days (IQR: 3–8) (Table 3). One in five patients suffered a complication (n = 182,628, 21.1%) and 2% (n = 13,172) died following surgery. Among individuals who suffered a complication, 7% died (n = 13,172) and 1 in 50 surgical patients experienced a "never event" (n = 18,465, 2.1%). The median cost of surgery was $21,400 (IQR: $14,900–36,200).

Patient and hospital characteristics by Hospital's safety net burden

Four tiers of hospital SN burden were identified: lowest, low, high, highest. Most patients underwent an operation at a hospital classified in either the lowest or low SN burden tier (n = 527,977, 61.0%); a smaller subset of patients was operated at a hospital in the high (n = 293,087, 33.9%) or highest (n = 44,584, 5.2%) SN burden categories. Details of patient characteristics stratified by SN burden tier were summarized in Table 1. Hospitals in the highest SN burden category had a younger patient population (median age: 62 years [IQR 52–69] vs. 64 years [IQR 56–71]; $p < 0.001$). While the overall proportion of racial/ethnic minority (African American [AA]/Blacks, Hispanic and other) patients was only 18.7% of the surgical cohort, hospitals in the highest SN burden tier had a much higher proportion of minority patients (n = 20,813, 46.7%). Hospitals with the highest SN burden were also more likely to care for patients with extreme loss of function (n = 6,554, 14.7% vs. n = 17,274, 7.4%; $p < 0.001$) and extreme likelihood of death (n = 4,931, 11.1% vs. n = 13,888, 6%; $p < 0.001$). The proportion of patients who were admitted emergently/urgently also increased with SN burden.

Table 1
Patient demographics and clinical characteristics of patients undergoing surgery stratified by safety net (SN) burden tier.

	Total N = 865,648	Lowest SN Burden N = 232,629	Low SN Burden N = 295,348	High SN Burden N = 293,087	Highest SN Burden N = 44,584	p
Age (median, IQR)	64 (55, 71)	64 (56, 71)	64 (55, 71)	63 (55, 71)	62 (52, 69)	<0.001
Female	397569 (45.9%)	109188 (46.9%)	136012 (46.1%)	132982 (45.4%)	19387 (43.5%)	<0.001
Race						
White	704042 (81.3%)	200107 (86%)	252608 (85.5%)	227556 (77.6%)	23771 (53.3%)	
AA/Black	72696 (8.4%)	13572 (5.8%)	19741 (6.7%)	31406 (10.7%)	7977 (17.9%)	
Hispanic/Other	88910 (10.3%)	18950 (8.1%)	22999 (7.8%)	34125 (11.6%)	12836 (28.8%)	
Elixhauser Comorbidity Burden	2 (1, 4)	2 (1, 3)	2 (1, 4)	2 (1, 4)	2 (1, 4)	<0.001
Mortality Category						<0.001
Minor likelihood of dying	472611 (54.6%)	140055 (60.2%)	163635 (55.4%)	148397 (50.6%)	20524 (46%)	
Moderate likelihood of dying	208588 (24.1%)	52249 (22.5%)	70794 (24%)	73979 (25.2%)	11566 (25.9%)	
Major likelihood of dying	117207 (13.5%)	26437 (11.4%)	39209 (13.3%)	43998 (15%)	7563 (17%)	
Extreme likelihood of dying	67242 (7.8%)	13888 (6%)	21710 (7.4%)	26713 (9.1%)	4931 (11.1%)	
Illness severity category						
Minor loss of function	245827 (28.4%)	75225 (32.3%)	84840 (28.7%)	75538 (25.8%)	10224 (22.9%)	
Moderate loss of function	359296 (41.5%)	99284 (42.7%)	123586 (41.8%)	119185 (40.7%)	17241 (38.7%)	
Major loss of function	175436 (20.3%)	40846 (17.6%)	59653 (20.2%)	64372 (22%)	10565 (23.7%)	
Extreme loss of function	85089 (9.8%)	17274 (7.4%)	27269 (9.2%)	33992 (11.6%)	6554 (14.7%)	
Median Household Income						<0.001
Quartile 1	205699 (23.8%)	35429 (15.2%)	61092 (20.7%)	91933 (31.4%)	17245 (38.7%)	
Quartile 2	220983 (25.5%)	46989 (20.2%)	81224 (27.5%)	81632 (27.9%)	11138 (25%)	
Quartile 3	217606 (25.1%)	57538 (24.7%)	82199 (27.8%)	68439 (23.4%)	9430 (21.2%)	
Quartile 4	221360 (25.6%)	92673 (39.8%)	70833 (24%)	51083 (17.4%)	6771 (15.2%)	
Procedure						<0.001
Colectomy	283606 (32.8%)	64261 (27.6%)	97769 (33.1%)	102274 (34.9%)	19302 (43.3%)	
CABG	248403 (28.7%)	58809 (25.3%)	82288 (27.9%)	93297 (31.8%)	14009 (31.4%)	
THA	333639 (38.5%)	109559 (47.1%)	115291 (39%)	97516 (33.3%)	11273 (25.3%)	
Emergent/Urgent Admission	270113 (31.2%)	56264 (24.2%)	87928 (29.8%)	105846 (36.1%)	20075 (45%)	

CABG: coronary artery bypass grafting; THA: total hip arthroplasty.

Specifically, nearly half of surgical admissions at hospitals with the highest SN burden were emergent/urgent (n = 20,075, 45%), whereas only 24% (n = 56,264) of admissions at hospitals in the lowest SN burden category were considered emergent/urgent. Furthermore, hospitals in the lowest SN burden tier were more likely to perform THA (n = 109,559, 47.1%), whereas procedures such as abdominal colectomy (n = 19302, 43.3%) were more likely to be performed at hospitals in the highest SN burden category.

Examination of the distribution of the SN burden at the 3090 hospitals in the cohort revealed that 1 in 10 hospitals were categorized in the highest SN category (n = 322, 10.4%) (Fig. 1). Additional details of hospital characteristics stratified by SN burden tier were summarized in Table 2. Hospitals in the lowest SN burden tier were more likely to be small (n = 401, 59.6%), while hospitals with the largest SN burden were more likely to be large (n = 125, 38.8%) and be an urban teaching facility (n = 182, 56.5%).

Patient outcomes relative to hospital SN burden

Compared with patients who underwent surgery at the lowest SN burden hospitals, patients operated at hospitals with the highest SN burden were nearly twice as likely to have a complication following surgery (n = 12,890, 28.9% vs. n = 39,830, 17.1%; p < 0.001) (Table 3). Specifically, surgical hospitalization at a high SN burden hospital was more likely to be complicated by pulmonary failure, pneumonia, myocardial infarction, acute renal failure and surgical site infection (all p < 0.001). In addition, the risk of death following a complication increased as SN burden increased (n = 1171, 2.6% vs n = 2527, 1.1%; p < 0.001). The risk of a never event was also more than two-fold higher at hospitals in the

Table 2
Hospital Characteristics stratified by safety net (SN) burden tier.

	Total N = 3090	Lowest SN burden N = 673	Low SN burden N = 916	High SN burden N = 1179	Highest SN burden N = 322	p
SN inpatient proportion (median, IQR)	24.23 (16.22, 32.75)	9.79 (6.47, 12.35)	20.09 (17.68, 22.32)	30.83 (27.27, 35.1)	52.26 (45.96, 63.16)	–
Size of Hospital						<0.001
Small	1127 (36.5%)	401 (59.6%)	345 (37.7%)	298 (25.3%)	83 (25.8%)	
Medium	963 (31.2%)	168 (25%)	299 (32.6%)	382 (32.4%)	114 (35.4%)	
Large	1000 (32.4%)	104 (15.5%)	272 (29.7%)	499 (42.3%)	125 (38.8%)	
Teaching Status						<0.001
Rural	803 (26%)	138 (20.5%)	241 (26.3%)	371 (31.5%)	53 (16.5%)	
Urban non-teaching	1126 (36.4%)	320 (47.5%)	328 (35.8%)	391 (33.2%)	87 (27%)	
Urban teaching	1161 (37.6%)	215 (31.9%)	347 (37.9%)	417 (35.4%)	182 (56.5%)	
Region of Hospital						<0.001
Northeast	530 (17.2%)	157 (23.3%)	180 (19.7%)	151 (12.8%)	42 (13%)	
Midwest	789 (25.5%)	189 (28.1%)	309 (33.7%)	252 (21.4%)	39 (12.1%)	
South	1165 (37.7%)	230 (34.2%)	302 (33%)	521 (44.2%)	112 (34.8%)	
West	606 (19.6%)	97 (14.4%)	125 (13.6%)	255 (21.6%)	129 (40.1%)	

IQR: interquartile range.

Table 3
Patient Outcomes following surgery stratified by hospital safety net (SN) burden tier.

	Total N = 865,648	Lowest SN Burden N = 232,629	Low SN Burden N = 295,348	High SN Burden N = 293,087	Highest SN Burden N = 44,584	p
Any complication	182628 (21.1%)	39830 (17.1%)	59542 (20.2%)	70366 (24%)	12890 (28.9%)	<0.001
Pulmonary failure	29314 (3.4%)	5606 (2.4%)	9205 (3.1%)	11752 (4%)	2751 (6.2%)	
Pneumonia	12345 (1.4%)	2570 (1.1%)	4016 (1.4%)	4782 (1.6%)	977 (2.2%)	
Myocardial infarction	74905 (8.7%)	15719 (6.8%)	24532 (8.3%)	29791 (10.2%)	4863 (10.9%)	
DVT/PE	9456 (1.1%)	2123 (0.9%)	2979 (1%)	3647 (1.2%)	707 (1.6%)	
Acute Renal Failure	74358 (8.6%)	16244 (7%)	23729 (8%)	28916 (9.9%)	5469 (12.3%)	
Hemorrhage	20983 (2.4%)	5135 (2.2%)	6951 (2.4%)	7611 (2.6%)	1286 (2.9%)	
Surgical Site Infection	27618 (3.2%)	6059 (2.6%)	8917 (3%)	10321 (3.5%)	2321 (5.2%)	
GI Hemorrhage	2623 (0.3%)	527 (0.2%)	807 (0.3%)	1032 (0.4%)	257 (0.6%)	
Failure to Rescue	13172 (7.2%)	2527 (6.3%)	4297 (7.2%)	5177 (7.4%)	1171 (9.1%)	<0.001
Mortality	13172 (1.5%)	2527 (1.1%)	4297 (1.5%)	5177 (1.8%)	1171 (2.6%)	<0.001
Never event	18465 (2.1%)	3792 (1.6%)	5807 (2%)	7068 (2.4%)	1798 (4%)	<0.001
LOS	5 (3, 8)	4 (3, 7)	5 (3, 8)	5 (3, 9)	6 (4, 11)	<0.001
Expenditure, median (K, USD)	21.4 (14.9, 36.2)	19.1 (13.9, 32.0)	20.8 (14.9, 35.0)	23.5 (15.9, 39.5)	26.1 (16.4, 44.1)	<0.001

DVT: deep vein thrombosis; GI: gastrointestinal; LOS: length of stay; PE: pulmonary embolus.

highest versus lowest SN burden tier (n = 1,798, 4% vs. n = 3,792, 1.6%; $p < 0.001$). Surgery at highest SN burden hospitals was associated with a median increased cost of $7000 compared with lowest SN burden hospitals ($26,100 [IQR $16,400-$44,100] vs. $19,100 [IQR $13,900–32,000], $p < 0.001$).

On multivariable logistic regression analysis, hospital SN burden status remained associated with outcomes following surgery (Table 4). Specifically, compared with patients who had an operation at the lowest SN burden hospital, patients operated at hospitals with the highest SN burden category were more likely to suffer a complication (OR 1.14, 95% CI 1.10–1.18). In addition, the odds of death following a complication incrementally increased as SN burden increased with patients at the highest SN burdened hospitals having 36% greater odds (OR 1.36, 95% CI 1.25–1.47) of FTR. The odds of a never event was, however, comparable across hospitals irrespective of hospital SN burden ($p > 0.05$). These findings were consistent after stratifying for procedure type (Supplemental Table 1).

Influence of race/ethnicity on outcomes

After adjusting for relevant clinical and hospital covariates, AA/Blacks had greater odds of experiencing a complication compared with White patient patients across all hospital SN burden tiers (all $p < 0.05$) (Fig. 2, Supplemental Table 2). In addition, minority patients also had greater odds of an extended LOS versus White patients even at the lowest burdened hospitals (OR 1.38, 95%CI 1.3–1.47). In contrast, the odds of death, FTR, and a never event was similar among AA/Black and White patients across all SN Burden tiers ($p < 0.05$). Similar trends were noted among individuals of Hispanic/Other race. Specifically, Hispanics/other patients had increased odds of a complication and prolonged LOS versus White patients across all SN burden categories ($p < 0.05$).

Discussion

Diversity in the United States is rapidly expanding with no racial or ethnic group being projected to be in the majority by 2065.[1] Experience and access with the healthcare system has not been equitable across racial groups, which has resulted in disparities in health outcomes. One initiative that has been proposed to help mitigate health disparities has been the establishment and financial support of SN hospitals, which aim to serve as places of care for vulnerable populations. With the repeal of the individual mandate penalty, worsening of health disparities among minority patients may become more pronounced, making SN hospitals even more important. The current study was important because the NIS dataset was used to examine health outcomes at SN hospitals following common surgical procedures such as colectomy, CABG, or THA. In particular, we examined the impact of SN hospitals relative to outcomes among surgical patients treated at lowest/low versus high/highest SN burden hospitals with a particular focus on the impact of racial/ethnic minority status relative to perioperative outcomes and SN burden. Perhaps not surprising, patients who received surgical care at a hospital in the highest SN burden category were more likely to be younger, a racial/ethnic minority, be low income, as well as present with more severe illness. Of note, SN burden was associated with worse peri-operative outcomes including higher likelihood of complications, FTR, extended LOS, as well as a “never” event following surgery. In examining the association between race/ethnicity and peri-operative outcomes, irrespective of the degree of hospital SN burden, racial/ethnic

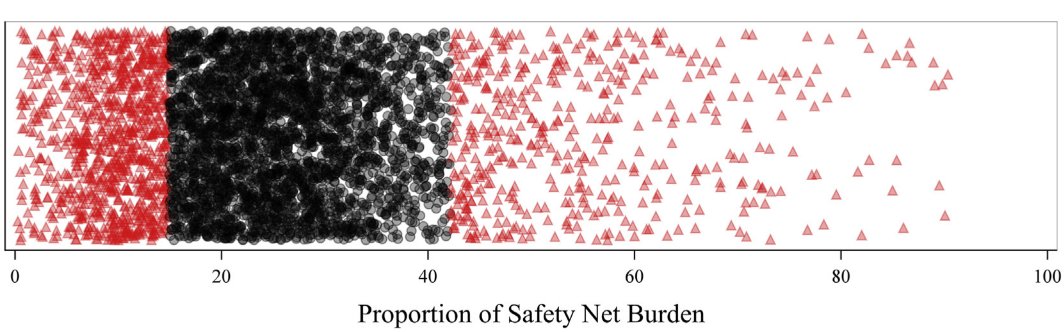

Fig. 1. Distribution of the safety net burden of the 3090 hospitals in the analytic cohort.

Table 4
Results of multivariable logistic regression analysis for evaluating the association of hospital's safety net burden for outcomes of interest following surgery. Each model controlled for procedure type, patient age, gender, race, year of procedure, Charlson Comorbidity Index, income quartile, hospital teaching status, hospital bed size, region of U.S., and whether the procedure was elective.

Safety net burden tier	Complication	FTR	Extended LOS	Death	Never Event
Lowest	Ref	Ref	Ref	Ref	Ref
Low	1.00 (0.98, 1.02)	1.07 (1.01, 1.12)	0.95 (0.93, 0.97)	1.07 (1.02, 1.13)	1.02 (0.98, 1.07)
High	1.03 (1.01, 1.05)	1.08 (1.02, 1.14)	1.04 (1.02, 1.06)	1.10 (1.05, 1.16)	1.01 (0.96, 1.06)
Highest	1.14 (1.10, 1.18)	1.36 (1.25, 1.47)	1.39 (1.34, 1.43)	1.41 (1.31, 1.52)	1.57 (1.47, 1.68)

FTR: failure to rescue, LOS: length of stay.

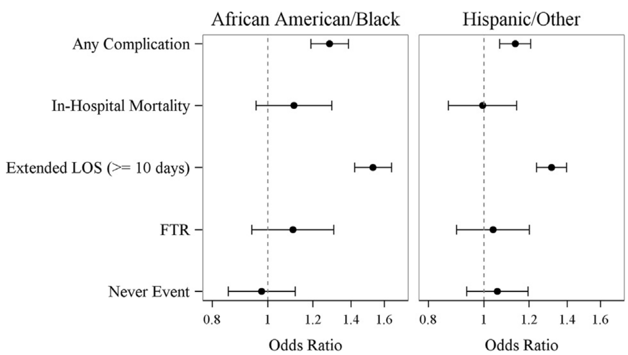

Fig. 2. At Hospitals in the highest safety net burden tier, the association between post-surgical outcomes and race/ethnicity (reference: Non-Hispanic White).

minorities had greater odds of a complication and extended LOS. Collectively the data demonstrated that, while more commonly treating African American, Hispanic and low income individuals, SN hospitals were not able to mitigate health disparities among minority patients.

Individuals who received care at hospitals with the greatest SN burden had distinct demographic characteristics including younger age, minority status, as well as lower income levels. In a study of the University HealthSystem Consortium database, Hoehn et al. similarly noted that patients treated at SN hospitals were more likely to be lower income and racial/ethnic minorities.[27] While this previous study simply described the demographic profile of patients at SN hospitals, the current study additionally characterized the health status of these individuals using the risk of mortality and severity of illness score. Of note, individuals who underwent an operation at one of the highest SN burdened hospitals were more commonly characterized with preoperative loss of function and higher likelihood of death. In a separate study, Dhar and colleagues had failed to note a difference in severity of illness among patients undergoing emergency general surgery based on severity of illness scores at SN hospitals.[28] The discrepant results are undoubtedly multifactorial, but likely reflect differences in patients at SN versus non-SN hospitals among patients undergoing emergency versus elective surgery. In particular, data from the current study would strongly suggest that patients undergoing elective non-emergent general at SN are generally sicker with more baseline morbidities. In turn, perhaps not surprisingly, outcomes following surgery at the highest SN burdened hospitals were worse. Hoehn et al. similarly noted higher odds of mortality and cost of care at high burdened hospitals, yet had attributed these variations to intrinsic qualities of SN hospitals due to the noted worse performance in Surgical Care Improvement Project measures.[27] In the current study, we similarly noted that the incidence of never events within the surgical population was highest among high SN burden hospitals, as patients at high SN burden hospitals were at an over 50% increased risk of a never event compared with patients undergoing an operation at the lowest burdened hospital. In turn, the data suggest that the worse outcomes at high SN burdened hospitals may be due to both structural processes unique to these hospitals (i.e. higher never events), as well as an adverse patient-case mix (i.e. more patients with higher medical acuity, comorbidities, etc.). As such, the quality of care received by patients at the highest SN burdened hospitals may not be equitable to care rendered at hospitals with a lower SN burden. Further research is needed to examine the organizational infrastructure at these institutions in order to improve the quality of care delivered to medically at-risk populations and ensure equitable care for all individuals.

The financial viability of SN hospitals has recently come into question. In 2016, hospitals provided more than $38.3 billion in uncompensated care of which only roughly 65% was offset by government funding.[29] The combination of decreasing disproportionate-share hospital payments to counterbalance for uncompensated care, as well as the 13 million additional uninsured people anticipated by 2027 after the repeal of the individual mandate penalty, could lead to a significant financial crisis for hospitals that are providing care to under-resourced populations.[30] In turn, the financial instability of high SN burdened institutions may create an organizational infrastructure that is ill-equipped and poorly resourced to care for complex, sick patients. Interestingly, we noted that the majority of high SN burden hospitals were large teaching institutions. Thus, in addition to the commitment to provide care to at risk populations, these SN hospitals are often training and developing the future surgical workforce. Financial jeopardy or closure of these institutions would serve only to exacerbate general surgery workforce issues, as well as worsen access to hospitals that perform inpatient surgery.[31,32] As such, alternative methods to financially support high burden SN institutions may be necessary and we should be looking for ways to reward institutions that are addressing social determinants of health.[33] For example, initiatives such as the Boston Medical Center Preventive Food Pantry and the Boston Health Care for the Homeless Program, have been created in order to improve surgical access and outcomes for individuals from underserved populations.[34] Further research is needed to determine if these interventions will be able to improve healthcare for vulnerable populations.

The current study also served to highlight the importance of assessing and screening for social determinants of health as a means to risk stratify patients undergoing surgical intervention. Social determinants of care include the conditions in which one lives, learns, worships, and works that, in turn, affect health risks and outcomes.[35] Though SN hospitals are able to provide needed surgical care for thousands of individuals, minorities had greater odds of complications across all hospitals irrespective of SN burden. These data emphasize how minority patients are at a disadvantaged state with higher risks of adverse outcomes due to worse underlying health conditions, as well as complicated social determinants of health. SN hospitals, while serving a greater proportion of minorities, are not often well positioned to impact these social determinants of health. For example, low-income neighborhoods have worse access to food sources (i.e. "food deserts"), which promote unhealthy eating choices compared with high-income neighborhoods.[36] As nutrition is an essential part of health and recovery following surgery, these individuals may be consequently at greater risk for poor wound healing, infections and complications following gastrointestinal, cardiac, and orthopedic surgery.[37,38] In another study, Wolf et al. noted that among new Medicare enrollees, individuals who were health illiterate had greater difficulties with activities of daily living and had more workplace challenges due to their physical health.[39] It is important to note that social determinants of health such as economic stability, education, and social and community support are not incorporated into commonly used risk stratification tools. As such, the worse clinical outcomes at high SN burden hospitals are likely not appropriately or accurately risk-stratified to take all of these factors into account.

Several limitations should be considered when interpreting the results of the current study. While SN burden was determined using previous established methodology, no consensus definition exists on how to best define SN hospitals.[40] Nonetheless, the current study utilized a formula based on uncompensated care that has previously been demonstrated to detect hospitals treating those individuals who are most financially vulnerable.[40] Though more recent trends in outcomes at SN hospitals was limited by the current dataset, the findings remain applicable as 2014 was one of the latest years that reflected the ACA implementation. Similar to other studies utilizing large administrative data, the present study was also subject to information bias secondary to variation in coding practices. While we performed multivariable logistic regression analysis to account for confounding factors in the observed data, there are unobservable variables such as access to healthy food, health literacy, hospital and patient economic stability that may have influenced the association between SN burden and outcomes which could not be adjusted for in the analysis.

In conclusion, while patients who received surgical care at the highest SN burdened hospitals represented only a small proportion of the surgical population, these patients were more likely to have a complication, die following a complication, have a longer LOS and greater associated hospital costs. Moreover, irrespective of hospital SN burden, minoritiy patients had greater odds of a complication and prolonged LOS compared with White patients. While SN hospitals play an important role in caring for America's most vulnerable populations, SN hospitals cannot mitigate racial disparities secondary to social determinants of health. Further research is needed to determine the root cause of health inequities and determine strategies to address these in order to ensure equitable health for all.

Financial support

There was no financial support for this study.

Declaration of competing interest

None Declared.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2020.01.044.

References

1. Pew Research Center. Modern immigration wave brings 59 millions to U.S., driving population growth and change through 2065: views of immigration's impact on U.S. Society mixed. https://www.pewresearch.org/hispanic/2015/09/28/modern-immigration-wave-brings-59-million-to-u-s-driving-population-growth-and-change-through-2065/. Published 2015. Accessed August 8, 2019.
2. Kirby JB, Kaneda T. Unhealthy and uninsured: exploring racial differences in health and health insurance coverage using a life table approach. *Demography*. 2010;47(4):1035–1051.
3. Cohen RA, Martinez ME, Zammitti EP. Health insurance coverage: early release of estimates from the national health interview survey. Published 2016 https://www.cdc.gov/nchs/data/nhis/earlyrelease/insur201605.pdf; 2015. Accessed August 8, 2019.
4. Buchmueller TC, Levinson ZM, Levy HG, Wolfe BL. Effect of the affordable care Act on racial and ethnic disparities in health insurance coverage. *Am J Publ Health*. 2016;106(8):1416–1421.
5. Gaffney A, McCormick D. The Affordable Care Act: implications for health-care equity. *Lancet*. 2017;389(10077):1442–1452.
6. Applebaum B, Robbins S. Language access and health equity: changes under the affordable care Act. *J Health Care Poor Underserved*. 2016;27(2):416–426.
7. Paredes AZ, Idrees JJ, Beal EW, et al. Influence of English proficiency on patient-provider communication and shared decision-making. *Surgery*. 2018;163(6):1220–1225.
8. Smedley BD, Stith AY, Nelson AR, eds. *Unequal Treatment: Confronting Racial and Ethnic Disparities in Health Care*. 2003. Washington (DC).
9. Frieden TR, Centers for Disease C, Prevention. CDC health disparities and inequalities report - United States, 2013. Foreword. *MMWR Suppl*. 2013;62(3):1–2.
10. Haider AH, Dankwa-Mullan I, Maragh-Bass AC, et al. Setting a national agenda for surgical disparities research: recommendations from the national Institutes of health and American College of surgeons summit. *JAMA Surg*. 2016;151(6):554–563.
11. Nazha B, Mishra M, Pentz R, Owonikoko TK. Enrollment of racial minorities in clinical trials: old problem assumes new urgency in the age of immunotherapy. *Am Soc Clin Oncol Educ Book*. 2019;39:3–10.
12. Kim J, ElRayes W, Wilson F, et al. Disparities in the receipt of robot-assisted radical prostatectomy: between-hospital and within-hospital analysis using 2009-2011 California inpatient data. *BMJ Open*. 2015;5(4):e007409.
13. Price JT, Zimmerman LD, Koelper NC, Sammel MD, Lee S, Butts SF. Social determinants of access to minimally invasive hysterectomy: reevaluating the relationship between race and route of hysterectomy for benign disease. *Am J Obstet Gynecol*. 2017;217(5). e571-572 e510.
14. Turner M, Adam MA, Sun Z, et al. Insurance status, not race, is associated with use of minimally invasive surgical approach for rectal cancer. *Ann Surg*. 2017;265(4):774–781.
15. Won RP, Friedlander S, Lee SL. Outcomes and costs of managing appendicitis at safety-net hospitals. *JAMA Surg*. 2017;152(11):1001–1006.
16. Shubeck SP, Thumma JR, Dimick JB, Nathan H. Hot spotting as a strategy to identify high-cost surgical populations. *Ann Surg*. 2019;269(3):453–458.
17. Girotti ME, Shih T, Revels S, Dimick JB. Racial disparities in readmissions and site of care for major surgery. *J Am Coll Surg*. 2014;218(3):423–430.
18. Healthcare Cost and Utilization Project (HCUP). *NIS Overview*. Agency for Healthcare Research and Quality; 2019. Accessed August 8, 2019 www.hcup-us.ahrq.gov/nisoverview.jsp. Published.
19. Averill RF, Goldfield N, Hughes JS, et al. All patient refined diagnosis related groups. *Methodol. Overv.*; 2003. https://www.hcup-us.ahrq.gov/db/nation/nis/APR-DRGsV20MethodologyOverviewandBibliography.pdf. Accessed May 25, 2018.
20. Gani F, Ejaz A, Makary MA, Pawlik TM. Hospital markup and operation outcomes in the United States. *Surgery*. 2016;160(1):169–177.
21. Siracuse JJ, Paracha M, Farber A, et al. Never events after hepatopancreatobiliary operations. *Am J Surg*. 2018;216(6):1129–1134.
22. Centers for Medicare and Medicaid Services. Eliminating serious, preventable, and costly medical errors- never events. Accessed August 6, 2019 https://www.cms.gov/newsroom/fact-sheets/eliminating-serious-preventable-and-costly-medical-errors-never-events; 2006. Published.
23. Shah NK, Farber A, Kalish JA, et al. Occurrence of "never events" after major open vascular surgery procedures. *J Vasc Surg*. 2016;63(3):738–745. e728.
24. Sheetz KH, Dimick JB, Ghaferi AA. Impact of hospital characteristics on failure to rescue following major surgery. *Ann Surg*. 2016;263(4):692–697.
25. Burt CW, Arispe IE. Characteristics of emergency departments serving high volumes of safety-net patients: United States, 2000. *Vital Health Stat*. 2004;13(155):1–16.
26. Tan P-N, Steinbach M, Karpatne A, Kumar V. *Introduction to Data Mining*. 2 ed. Pearson; 2018.
27. Hoehn RS, Wima K, Vestal MA, et al. Effect of hospital safety-net burden on cost and outcomes after surgery. *JAMA Surg*. 2016;151(2):120–128.
28. Dhar VK, Kim Y, Wima K, Hoehn RS, Shah SA. The importance of safety-net hospitals in emergency general surgery. *J Gastrointest Surg*. 2018;22(12):2064–2071.
29. Coughlin TA, Holahan J, Caswell K, McGrath M. An estimated $84.9 billion in uncompensated care was provided in 2013; ACA payment cuts could challenge providers. *Health Aff (Millwood)*. 2014;33(5):807–814.
30. Congressional Budget Office. Repealing the individual health insurance mandate: an updated estimate. https://www.cbo.gov/system/files/115th-congress-2017-2018/reports/53300-individualmandate.pdf; 2017. Accessed May 20, 2019.
31. Diaz A, Schoenbrunner A, Pawlik TM. Trends in the geospatial distribution of

inpatient Adult surgical services across the United States. *Ann Surg*. 2019.
32. Ellison EC, Pawlik TM, Way DP, Satiani B, Williams TE. Ten-year reassessment of the shortage of general surgeons: increases in graduation numbers of general surgery residents are insufficient to meet the future demand for general surgeons. *Surgery*. 2018;164(4):726–732.
33. Nichols LM, Taylor LA. Social determinants as public goods: a new approach to financing key investments in healthy communities. *Health Aff (Millwood)*. 2018;37(8):1223–1230.
34. Robinson TD, Oliveira TM, Timmes TR, et al. Socially responsible surgery: building recognition and coalition. *Front Surg*. 2017;4:11.
35. Office of Disease Prevention and Health Promotion. *Healthy People 2020: An Opportunity to Address the Societal Determinants of Health in the United States*. U.S. Department of Health and Human Services; 2010. Accessed August 8, 2019 https://www.healthypeople.gov/2010/hp2020/advisory/SocietalDeterminantsHealth.htm. Published.
36. Hilmers A, Hilmers DC, Dave J. Neighborhood disparities in access to healthy foods and their effects on environmental justice. *Am J Publ Health*. 2012;102(9):1644–1654.
37. Stoppe C, Goetzenich A, Whitman G, et al. Role of nutrition support in adult cardiac surgery: a consensus statement from an international multidisciplinary expert group on nutrition in cardiac surgery. *Crit Care*. 2017;21(1):131.
38. Cross MB, Yi PH, Thomas CF, Garcia J, Della Valle CJ. Evaluation of malnutrition in orthopaedic surgery. *J Am Acad Orthop Surg*. 2014;22(3):193–199.
39. Wolf MS, Gazmararian JA, Baker DW. Health literacy and functional health status among older adults. *Arch Intern Med*. 2005;165(17):1946–1952.
40. Popescu I, Fingar KR, Cutler E, Guo J, Jiang HJ. Comparison of 3 safety-net hospital definitions and association with hospital characteristics. *JAMA Netw Open*. 2019;2(8). e198577.