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The effect of Hispanic ethnicity on surgical outcomes: An analysis of the NSQIP database

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ABSTRACT

Background: Existing literature has shown racial/ethnic disparities between white and black surgical populations, however, surgical outcomes for Hispanic patients are limited in both scope and quantity.
Methods: Data from the American College of Surgeons National Surgical Quality Improvement Program from 2007 to 2015 was used to analyze surgical outcomes in approximately 3.5 million patients.
Results: Overall, Hispanics experienced lower odds of mortality compared to non-Hispanic White, non-Hispanic Black, and non-Hispanic American Indian or Alaska Native patients (all $P < 0.0001$). No difference was found in mortality odds between Hispanics and non-Hispanic Asian or Native Hawaiian patients. Hispanics experienced minimal disparities in complications as compared to non-Hispanic White and non-Hispanic Black but had a higher rate of select complications when compared to Non-Hispanic Asian, Native Hawaiian, or Pacific Islander.
Conclusion: Hispanics, in general, had lower odds of 30-day postoperative mortality and major morbidity compared to most of the races/ethnicities included in the ACS NSQIP database.

Introduction

The existence of health disparities affecting racial and ethnic minorities in the United States is well known. Health status disparities refer to preventable differences in rates of disease occurrence or opportunities to achieve optimal health observed in socioeconomically disadvantaged populations.[1] Disparities in health outcomes have been documented in virtually all areas of medicine, for example, diabetes incidence and control,[2,3] prevalence of overweight and obesity,[4] incidence of liver disease,[5,6] prevalence of cardiovascular diseases,[7] limited access to healthcare,[8] and a lower quality of care.[9] The underlying phenomenon that allow these disparities to endure, however, are not completely understood.

Racial disparities in surgical outcomes have been well documented for black patients in the United States[10–12] but research examining other minority surgical outcomes is both limited and inconclusive. In the black surgical population, studies have reported higher 30-day postoperative mortality and higher postoperative morbidities including longer hospital stay, higher rates of cardiac arrest, renal insufficiency/failure, and postoperative infectious complications.[10–12] Explanations for these disparities are wide-ranging and have been attributed to inadequate access to care,[13] hospital volume,[14] lower socioeconomic status[15] and an independent association between race and poor postoperative outcomes.[10,13,16]

Other studies have reported that Hispanics have lower complication rates compared to whites after 6 commonly performed emergency procedures[16] and similar outcomes to whites in terms of in-hospital mortality after major cancer surgery.[10] Studies that have analyzed data from both cancer and non-cancer surgical procedures indicated that differences in 30-day mortality,

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readmission rates, length of stay, and major complication rate varied greatly and depended on surgery type.[17,18]

While there is a body of literature suggesting that racial and ethnic disparities exist for postoperative outcomes, there are important limitations to those studies. First, previous studies have mostly focused on the differences between Caucasian and African American populations. Few studies have analyzed surgical outcomes among non-Black minority racial and ethnic groups. Secondly, the studies tended to focus on a single surgical discipline or specific surgical intervention and used a limited data set that may not be used to extrapolate national trends.[19–21]

Our objective was to use the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP) dataset to provide a comprehensive analysis of the impact of the Hispanic race on surgical outcomes. We conducted a retrospective cross-sectional study to determine if the ACS-NSQIP database outcomes could determine whether or not a legitimate difference exists between Hispanic and non-Hispanic patients.

Methods

Study population

ACS-NSQIP provides annual Participant Use Data Files (PUF) that comprise a collection of patient records compiled from patient medical charts from approximately 700 hospitals in the US, Canada, Australia, Italy, Japan, United Kingdom and Germany to track surgical morbidity and mortality outcomes for all major inpatient and outpatient surgical procedures.[22] Our study used PUF data sets from 2007 to 2015 and all patients, regardless of surgery type, were included in the analysis.

The database is comprised of adults 18 years of age and older and the race variable includes American Indian or Alaska Native, Asian, Black or African American, Native Hawaiian or Pacific Islander, Unknown/Not Reported, and White. Exclusion criteria were patients under the age of 18, trauma cases, transplant cases, patients assigned an ASA score of 6 (brain-death organ donors), and minor cases.[22]

Outcome variables

The outcome variables of interest were mortality and major postoperative complications which included deep incisional surgical site infection, organ/space surgical site infection, wound disruption, pneumonia, unplanned intubation, pulmonary embolism, ventilator-assisted respirations > 48 h, progressive renal insufficiency, acute renal failure, CVA/stroke with neurological deficit, cardiac arrest requiring CPR, myocardial infarction, sepsis, septic shock, return to the operating room, days from operation to death and total length of hospital stay. Variables that were no longer in use in the NSQIP database were not included in the analysis.

Independent variables

The main predictor of interest was the ethnicity variable. Race and ethnicity were coded as one variable in early versions of the NSQIP database. Starting in 2008, race and ethnicity were coded as two independent variables. For the purpose of this study and to include all data classified in both versions of the race/ethnicity coding, a new race/ethnicity categorical variable was created with six categories: Hispanic, non-Hispanic White, non-Hispanic Black, non-Hispanic Asian or Pacific Islander, non-Hispanic American Indian or Alaska Native, and unknown race/ethnicity. Other covariates of interest considered in this analysis were age, gender, body mass index (BMI), and preoperative conditions. Body mass index (BMI) was calculated by multiplying weight in pounds by 703, then dividing by height squared in inches (lb/in^2). BMI groups were created as: underweight (BMI < 18.5 lb/in^2), normal weight (BMI 18.5 lb/in^2 to 24.9 lb/in^2), overweight (BMI 25 lb/in^2 to 29.9 lb/in^2), obese (BMI 30 lb/in^2 to 39.9 lb/in^2), and extremely obese (BMI ≥40 lb/in^2).[23] Preoperative conditions included ascites, bleeding disorders, dialysis, disseminated cancer, dyspnea, emergency case, functional health status prior to surgery, history of congestive heart failure in 30 days prior to surgery, history of severe COPD, hypertension requiring medication, systemic sepsis, acute renal failure, smoking within one year of surgery, steroid use for chronic condition, surgical specialty, principal anesthesia technique, transfusions 72 h prior to surgery, ventilator dependence, preoperative evidence of wound infection, more than 10% loss body weight six months prior to surgery, and diabetes mellitus. Diabetes variable was classified in three categories: patients with no diagnosis of diabetes, patients with a diagnosis of diabetes requiring a non-insulin oral agent, and patients with diabetes requiring insulin therapy. Since every new dataset added approximately 500,000 new subjects, to avoid data truncation, variables that were no longer collected by NSQIP were not included in the analysis.

Statistical analyses

Descriptive statistics for patient demographics, pre-operative characteristics, and post-operative complications were generated for the entire study population and by Hispanic and non-Hispanic groups. Continuous variables were summarized and reported with means and standard deviations, and frequencies and percentages were used to describe the categorical variables. Pearson's chi-square and student's t-test were used to compare the distribution of categorical and continuous variables, respectively between Hispanic and non-Hispanic groups. Separate univariable and multivariable logistic regression models were used to calculate crude and adjusted odds ratios (OR) and their 95% confidence intervals (CI) and to determine independent factors associated with post-operative complications. Post-hoc multiple pairwise comparisons of means between the six race/ethnicity defined groups were conducted using Tukey-Kramer test. Univariable and multivariable zero-inflated negative binomial regressions were used to determine if the rate of variable length of stay in the hospital measured in days was related to patient race/ethnicity and any of the specified preoperative covariates of interest. Additional regression models were created to determine whether the post-operative complications had an effect on the length of hospital stay. Assessment for potential multicollinearity impact and two-way interaction effects between the predictors included in the multivariable regression models were performed. All statistical analyses were carried out using SAS 9.4 (SAS Institute, Inc). All statistical tests were two-sided and were performed using significance (alpha) level of 0.05.

Results

Characteristics of the study population

A total of 3, 490, 247 patients between 18 and 99 years of age from the NSQIP data from 2007 to 2015 years were analyzed. The descriptive statistics for patient demographic and pre-operative characteristics are presented in Table 1 and Table 2, respectively. Hispanics comprised 7.18% of the study population, White-69.7%, Black-9.6%, Asian, Native Hawaiian, or Pacific Islander-2.6%, American Indian or Alaska Native-0.6%, and 10.3% of the participants' ethnicity and/or race was unknown (Table 1). The mean (SD) age of

Table 1
Patient demographic and pre-operative characteristics for the total study population and by Hispanic and Non-Hispanic groups using the NSQIP data from 2007 to 2015.

Patient demographic and pre-operative characteristics	Total n = 3,490,247	Hispanic n = 250,727 (7.18%)	White n = 2,433,675 (69.73%)	Black n = 336,327 (9.64%)	American Indian or Alaska Native n = 20,232 (0.58%)	Asian and Others n = 89,689 (2.57%)
Continuous variable	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Age (years)	55.9 (16.45)	49.3 (16.72)	57.3 (16.17)	52.4 (15.73)	50.2 (16.06)	53.8 (16.64)
BMI (lb/in^2)	30 (7.73)	30.5 (7.39)	29.9 (7.65)	31.9 (8.87)	31.1 (7.87)	26.4 (6.04)
Weight (lb)	187.6 (51.26)	181.1 (47.07)	188.6 (51.16)	198.8 (55.57)	187.6 (51.36)	155 (41.1)
Height (in)	66.2 (3.99)	64.6 (3.63)	66.5 (3.99)	66.3 (3.92)	65 (3.86)	64.1 (3.49)
Death within 30 days (days)	11.5 (8.79)	11.5 (8.93)	11.5 (8.76)	11.6 (8.86)	11.2 (8.93)	11.5 (8.83)
Length of hospital stay (days)	3.8 (8.3)	3.2 (8.06)	3.7 (8.05)	4.8 (9.56)	3.7 (8.36)	3.6 (8.66)
Categorical variable	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Sex						
Male	1,509,602 (43.3)	100,212 (39.98)	1,080,447 (44.41)	120,772 (35.93)	7908 (39.14)	37,830 (42.2)
Female	1,976,837 (56.7)	150,430 (60.02)	1,352,192 (55.59)	215,368 (64.07)	12,297 (60.86)	51,814 (57.8)
BMI groups						
Underweight (BMI<18)	46,346 (1.33)	1876 (0.75)	32,447 (1.33)	5425 (1.61)	199 (0.98)	1960 (2.19)
Normal (18 ≤ BMI<25)	908,473 (26.03)	54,166 (21.6)	637,949 (26.21)	69,355 (20.62)	4377 (21.63)	41,596 (46.38)
Overweight (25 ≤ BMI<30)	1,095,094 (31.38)	84,241 (33.6)	767,337 (31.53)	89,280 (26.55)	5661 (27.98)	28,254 (31.5)
Obese (30 ≤ BMI<40)	1,071,156 (30.69)	84,448 (33.68)	745,444 (30.63)	115,727 (34.41)	7481 (36.98)	14,613 (16.29)
Extremely obese (BMI≥40)	369,178 (10.58)	25,996 (10.37)	250,498 (10.29)	56,540 (16.81)	2514 (12.43)	3266 (3.64)
Current smoker within one year	662,116 (18.97)	36,239 (14.45)	464,461 (19.08)	81,917 (24.36)	7124 (35.21)	9677 (10.79)
Hypertension requiring medication	1,608,519 (46.09)	91,043 (36.31)	1,143,963 (47.01)	192,069 (57.11)	8098 (40.03)	36,439 (40.63)
Diabetes mellitus treatment						
Insulin	206,025 (5.90)	16,775 (6.69)	134,170 (5.51)	33,964 (10.1)	1371 (6.78)	4530 (5.05)
Non-Insulin	327,624 (9.39)	27,550 (10.99)	217,448 (8.93)	38,947 (11.58)	1797 (8.88)	10,706 (11.94)
None- or diet controlled - diabetes	2,956,596 (84.71)	206,402 (82.32)	2,082,056 (85.55)	263,416 (78.32)	17,064 (84.34)	74,452 (83.01)
Anesthesia technique						
Epidural	8181 (0.23)	419 (0.17)	5810 (0.24)	743 (0.22)	26 (0.13)	161 (0.18)
General	3,154,012 (90.38)	233,469 (93.13)	2,199,296 (90.38)	310,246 (92.26)	19,187 (94.84)	80,721 (90.01)
Local	13,182 (0.38)	876 (0.35)	9423 (0.39)	1247 (0.37)	25 (0.12)	417 (0.46)
MAC/IV Sedation	96,756 (2.77)	6444 (2.57)	67,288 (2.77)	9277 (2.76)	309 (1.53)	3035 (3.38)
Monitored Anesthesia Care	61,166 (1.75)	3281 (1.31)	45,478 (1.87)	5093 (1.51)	111 (0.55)	1490 (1.66)
Regional	27,762 (0.8)	1407 (0.56)	20,675 (0.85)	2072 (0.62)	81 (0.4)	729 (0.81)
Spinal	124,014 (3.55)	4576 (1.83)	82,008 (3.37)	7075 (2.1)	403 (1.99)	3025 (3.37)
Other	3560 (0.1)	161 (0.06)	2564 (0.11)	392 (0.12)	84 (0.42)	55 (0.06)
Unknown	423 (0.01)	46 (0.02)	241 (0.01)	40 (0.01)	2 (0.01)	33 (0.04)
None	692 (0.02)	19 (0.01)	536 (0.02)	90 (0.03)	2 (0.01)	14 (0.02)
Ascites	21,659 (0.62)	1322 (0.53)	15,593 (0.64)	2523 (0.75)	141 (0.7)	567 (0.63)
Bleeding disorders	170,473 (4.88)	8133 (3.24)	129,441 (5.32)	17,084 (5.08)	634 (3.13)	2945 (3.28)
Dialysis	54,867 (1.57)	4864 (1.94)	26,227 (1.08)	17,799 (5.29)	337 (1.67)	2019 (2.25)
Disseminated cancer	75,733 (2.17)	3758 (1.5)	55,552 (2.28)	6849 (2.04)	343 (1.7)	2330 (2.6)
Dyspnea						
At Rest	29,669 (0.85)	1465 (0.58)	21,723 (0.89)	3621 (1.08)	158 (0.78)	420 (0.47)
Moderate	255,018 (7.31)	10,306 (4.11)	193,517 (7.95)	26,821 (7.97)	986 (4.87)	2408 (2.68)
Emergency care	339,128 (9.72)	34,848 (13.9)	217,125 (8.92)	33,761 (10.04)	2269 (11.21)	12,429 (13.86)
Functional health status prior surgery						
Independent	3,340,765 (95.72)	240,274 (95.83)	2,332,756 (95.85)	315,342 (93.76)	19,403 (95.9)	85,625 (95.47)
Partially Dependent	106,613 (3.05)	7257 (2.89)	73,588 (3.02)	14,547 (4.33)	673 (3.33)	2038 (2.27)
Totally Dependent	31,274 (0.9)	2094 (0.84)	2,0640 (0.85)	5372 (1.6)	129 (0.64)	582 (0.65)
Unknown	11,592 (0.33)	1102 (0.44)	6689 (0.27)	1066 (0.32)	27 (0.13)	1443 (1.61)
Congestive heart failure in 30 days before surgery	30,064 (0.86)	1830 (0.73)	20,418 (0.84)	4634 (1.38)	131 (0.65)	531 (0.59)
History of severe COPD	161,810 (4.64)	4640 (1.85)	129,796 (5.33)	12,542 (3.73)	918 (4.54)	1341 (1.5)
Systematic sepsis						

Table 1 (*continued*)

Patient demographic and pre-operative characteristics	Total n = 3,490,247	Hispanic n = 250,727 (7.18%)	White n = 2,433,675 (69.73%)	Black n = 336,327 (9.64%)	American Indian or Alaska Native n = 20,232 (0.58%)	Asian and Others n = 89,689 (2.57%)
Continuous variable	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
SIRS	127,151 (3.66)	12,857 (5.14)	85,061 (3.51)	14,119 (4.21)	749 (3.72)	3878 (4.33)
Sepsis	68,194 (1.96)	6023 (2.41)	44,608 (1.84)	9773 (2.92)	433 (2.15)	1965 (2.19)
Septic Shock	18,729 (0.54)	1042 (0.42)	13,123 (0.54)	2449 (0.73)	157 (0.78)	422 (0.47)
Acute renal failure (pre-op)	15,167 (0.43)	1142 (0.46)	8734 (0.36)	3581 (1.06)	96 (0.47)	440 (0.49)
Steroid use for chronic condition	118,610 (3.4)	6047 (2.41)	87,532 (3.6)	12,619 (3.75)	651 (3.22)	2215 (2.47)
Transfusion >4 units PRBCs in 72 h before surgery	30,228 (0.87)	2104 (0.84)	18,960 (0.78)	5199 (1.55)	160 (0.79)	933 (1.04)
Ventilator dependent	19,436 (0.56)	1028 (0.41)	13,212 (0.54)	2832 (0.84)	141 (0.7)	448 (0.5)

the studied population was 55.9 (16.45) years. On average, Hispanics were significantly younger (49.3 (16.72) years) than all other non-Hispanic race/ethnicity groups (Tukey-Kramer adjusted p-values<0.001). Females were predominant in the entire study population (56.7%) as well as in all race/ethnicity groups (Hispanic-60.02%, White-55.59%, Black-64.07%; Asian and Pacific Islander-57.8%, and American Indian and Alaska Native-60.86%) ($p < 0.0001$) (Table 1). Significantly high was the proportion of overweight and obese in Hispanics (77.65%) compared to the rest of the ethnic groups ($p < 0.0001$) (Table 1). Nearly 22% of Black patients, 18% of Hispanics, 17% of Asians and Pacific Islanders, and 16% of American Indians and Alaska Native had diabetes mellitus that required a non-insulin oral agent or insulin therapy ($p < 0.0001$) (Table 1).

Table 2
Major surgery procedures and post-operative outcomes for the total study population and by Hispanic and Non-Hispanic groups using the NSQIP data from 2007 to 2015.

Surgery procedures	Total n = 3,490,247	Hispanic n = 250,727 (7.18%)	White n = 2,433,675 (69.73%)	Black n = 336,327 (9.64%)	American Indian or Alaska Native n = 20,232 (0.58%)	Asian and Others n = 89,689 (2.57%)
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Cardiac Surgery	20,699 (0.59)	1507 (0.6)	14,172 (0.58)	1072 (0.32)	108 (0.53)	391 (0.44)
General Surgery	2,014,704 (57.72)	153,409 (61.19)	1,405,774 (57.76)	207,273 (61.63)	12,633 (62.44)	55,222 (61.57)
Gynecology	195,408 (5.6)	22,468 (8.96)	116,713 (4.8)	24,340 (7.24)	1304 (6.45)	6678 (7.45)
Interventional Radiologist	348 (0.01)	14 (0.01)	298 (0.01)	20 (0.01)	3 (0.01)	5 (0.01)
Neurosurgery	129,486 (3.71)	7172 (2.86)	96,411 (3.96)	10,244 (3.05)	949 (4.69)	2451 (2.73)
Ophthalmology	1 (0)	0 (0)	1 (0)	0 (0)	0 (0)	0 (0)
Oral Surgery	19 (0)	3 (0)	11 (0)	4 (0)	0 (0)	1 (0)
Orthopedics	487,333 (13.96)	29,748 (11.86)	346,338 (14.23)	33,172 (9.86)	2755 (13.62)	10,670 (11.9)
Otolaryngology (ENT)	74,605 (2.14)	5363 (2.14)	48,131 (1.98)	5944 (1.77)	700 (3.46)	2987 (3.33)
Plastics	73,470 (2.11)	5478 (2.18)	45,222 (1.86)	7464 (2.22)	227 (1.12)	1476 (1.65)
Thoracic	36,636 (1.05)	1823 (0.73)	27,815 (1.14)	2486 (0.74)	99 (0.49)	876 (0.98)
Urology	145,229 (4.16)	9287 (3.7)	98,992 (4.07)	10,279 (3.06)	480 (2.37)	3161 (3.52)
Vascular	312,228 (8.95)	14,455 (5.77)	23,3731 (9.6)	34,025 (10.12)	973 (4.81)	5770 (6.43)
Postoperative outcomes	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**	**n (%)**
Deep Incisional SSI	22,797 (0.65)	1496 (0.6)	15,722 (0.65)	2911 (0.87)	168 (0.83)	358 (0.4)
Organ Space SSI	42,954 (1.23)	2677 (1.07)	30,740 (1.26)	4268 (1.27)	263 (1.3)	1155 (1.29)
Wound Disruption	16,551 (0.47)	908 (0.36)	11,829 (0.49)	1950 (0.58)	188 (0.93)	235 (0.26)
Pneumonia	45,243 (1.3)	2046 (0.82)	32,779 (1.35)	4963 (1.48)	418 (2.07)	936 (1.04)
Unplanned Intubation	36,255 (1.04)	1625 (0.65)	26,415 (1.09)	4573 (1.36)	186 (0.92)	772 (0.86)
Ventilator > 48Hours	52,032 (1.49)	2534 (1.01)	37,056 (1.52)	6896 (2.05)	284 (1.4)	1138 (1.27)
Pulmonary Embolism	11,870 (0.34)	533 (0.21)	8613 (0.35)	1505 (0.45)	38 (0.19)	142 (0.16)
Progressive Renal Insufficiency	10,576 (0.3)	548 (0.22)	7203 (0.3)	1678 (0.5)	46 (0.23)	179 (0.2)
Acute Renal Failure	12,704 (0.36)	660 (0.26)	8834 (0.36)	1813 (0.54)	66 (0.33)	263 (0.29)
CVA/Stroke with neurological deficit	7583 (0.22)	344 (0.14)	5584 (0.23)	798 (0.24)	49 (0.24)	177 (0.2)
Cardiac Arrest Requiring CPR	11,901 (0.34)	635 (0.25)	7978 (0.33)	2025 (0.6)	49 (0.24)	287 (0.32)
Myocardial Infarction	11,860 (0.34)	449 (0.18)	8824 (0.36)	1064 (0.32)	47 (0.23)	237 (0.26)
Sepsis	58,249 (1.67)	3756 (1.5)	40,148 (1.65)	7937 (2.36)	323 (1.6)	1348 (1.5)
Septic Shock	30,575 (0.88)	1568 (0.63)	21,967 (0.9)	3685 (1.1)	199 (0.98)	682 (0.76)
Return to OR	132,869 (3.81)	7158 (2.85)	94,289 (3.87)	16,736 (4.98)	812 (4.01)	2665 (2.97)
Dies within 30 days (n = 3292070)	40,513 (1.23)	1857 (0.78)	29,897 (1.31)	4475 (1.41)	211 (1.12)	797 (0.93)

Table 3
Crude OR (95% CI)^ for the association between various patients demographic and pre-operative characteristics and mortality and major postoperative complications based on univariable logistic regression analysis using the NSQIP data from 2007 to 2015.

Patient demographic and pre-operative characteristics	Deep incision SSI	Organ space SSI	Wound disrupt	Pneumonia	Unplanned intubation	Ventilator >48 h	Pulmonary embolism	Progressive renal insufficiency
Age (years)	1.0096 (1.0087,1.0104)	1.0047 (1.0041,1.0053)	1.0158 (1.0148,1.0168)	1.0402 (1.0396,1.0409)	1.0463 (1.0455,1.0471)	1.0381 (1.0375,1.0388)	1.0281 (1.0269,1.0294)	1.0372 (1.0359,1.0386)
BMI	1.0206 (1.019,1.0221)	0.9887 (0.987,0.99)	1.0141 (1.012,1.016)	0.9708 (0.969,0.972)	0.9801 (0.9787,0.9816)	0.9959 (0.9948,0.9971)	1.0167 (1.0146,1.0189)	1.0166 (1.0143,1.0189)
Underweight vs Normal BMI	1.65 (1.49,1.82)	1.65 (1.55,1.76)	1.99 (1.79,2.21)	2.26 (2.14,2.37)	2.17 (2.04 2.3)	2.22 (2.11,2.34)	1.4 (1.2,1.63)	1.62 (1.4,1.87)
Overweight vs Normal BMI	1.01 (0.98,1.05)	0.88 (0.86,0.91)	0.97 (0.93,1.01)	0.72 (0.7, 0.73)	0.77 (0.75,0.79)	0.82 (0.8,0.84)	1.23 (1.16,1.29)	1.06 (1,1.12)
Obese vs Normal BMI	1.32 (1.27,1.37)	0.84 (0.82,0.86)	1.2 (1.15,1.25)	0.64 (0.62,0.65)	0.71 (0.69,0.73)	0.84 (0.82,0.86)	1.52 (1.44,1.59)	1.24 (1.18,1.31)
Extremely Obese vs Normal BMI	1.64 (1.57,1.71)	0.81 (0.78,0.84)	1.45 (1.38,1.53)	0.59 (0.57,0.61)	0.69 (0.67,0.72)	0.96 (0.94,0.99)	1.51 (1.42,1.61)	1.53 (1.43,1.63)
Male	1.16 (1.13,1.19)	1.38 (1.36,1.41)	1.48 (1.44,1.53)	1.8 (1.76,1.83)	1.72 (1.68,1.75)	1.63 (1.6,1.66)	1.19 (1.15,1.24)	2.17 (2.09,2.26)
Hispanic vs White	0.92 (0.88,0.97)	0.84 (0.81,0.88)	0.74 (0.7,0.8)	0.6 (0.58,0.63)	0.59 (0.57,0.63)	0.66 (0.63,0.69)	0.6 (0.55,0.65)	0.74 (0.68,0.8)
Hispanic vs Black	0.69 (0.65,0.73)	0.84 (0.8,0.88)	0.62 (0.58,0.67)	0.55 (0.52,0.58)	0.47 (0.45,0.5)	0.49 (0.47,0.51)	0.47 (0.43,0.52)	0.44 (0.4,0.48)
Hispanic vs American Indian or Alaska Native	0.72 (0.61,0.84)	0.82 (0.72,0.93)	0.39 (0.33,0.45)	0.39 (0.35,0.43)	0.7 (0.6,0.82)	0.72 (0.63,0.81)	1.13 (0.81,1.57)	0.96 (0.71,1.3)
Hispanic vs Asian, Native Hawaiian, or Pacific Islander	1.5 (1.33,1.68)	0.83 (0.77,0.89)	1.38 (1.2,1.6)	0.78 (0.72,0.84)	0.75 (0.69,0.82)	0.79 (0.74,0.85)	1.34 (1.12,1.62)	1.1 (0.93,1.3)
Hispanic vs Unknown	1 (0.94,1.07)	1 (0.95,1.05)	0.9 (0.83,0.98)	0.71 (0.68,0.75)	0.87 (0.82,0.92)	0.88 (0.84,0.92)	0.74 (0.66,0.82)	0.85 (0.77,0.95)
Current smoker within one year	1.62 (1.58,1.67)	1.27 (1.24,1.3)	1.81 (1.75,1.87)	1.71 (1.67,1.74)	1.59 (1.55,1.63)	1.67 (1.63,1.7)	0.81 (0.77,0.85)	1.3 (1.24,1.36)
Hypertension requiring medication	1.59 (1.55,1.63)	1.1 (1.08,1.12)	1.69 (1.63,1.74)	2.27 (2.23,2.32)	2.93 (2.86,3)	2.6 (2.55,2.65)	1.55 (1.5,1.61)	3.65 (3.49,3.81)
Insulin	2.67 (2.57,2.78)	1.43 (1.38,1.48)	2.06 (1.96,2.16)	2.3 (2.24,2.37)	2.89 (2.81,2.98)	2.92 (2.85,2.99)	1.13 (1.05,1.21)	3.3 (3.13,3.48)
Non-Insulin Oral Agent	1.46 (1.41,1.52)	1.07 (1.04,1.11)	1.29 (1.23,1.36)	1.39 (1.35,1.43)	1.66 (1.61,1.71)	1.57 (1.53,1.61)	1.2 (1.14,1.28)	2.14 (2.03,2.25)
Epidural Anesthesia	1.25 (0.51,3.11)	0.74 (0.33,1.61)	2.72 (0.66,11.14)	2.17 (0.88,5.31)	0.89 (0.46,1.7)	1.41 (0.57,3.48)	3.82 (0.53,27.77)	0.99 (0.3,3.22)
General Anesthesia	0.95 (0.39,2.29)	1.33 (0.63,2.79)	1.75 (0.44,7.02)	1.92 (0.8,4.62)	0.77 (0.41,1.43)	2.27 (0.94,5.47)	2.43 (0.34,17.25)	0.74 (0.24,2.29)
Local Anesthesia	0.27 (0.1,0.71)	0.12 (0.05,0.29)	0.5 (0.12,2.14)	0.37 (0.14,0.94)	0.16 (0.08,0.33)	0.25 (0.1,0.66)	0.31 (0.04,2.62)	0.28 (0.08,0.96)
MAC/IV Sedation	0.45 (0.19,1.1)	0.21 (0.1,0.46)	0.41 (0.1,1.65)	0.67 (0.28,1.63)	0.24 (0.13,0.46)	0.29 (0.12,0.7)	1.19 (0.17,8.54)	0.32 (0.1,1)
Monitored Anesthesia Care	0.22 (0.09,0.54)	0.09 (0.04,0.2)	0.36 (0.09,1.46)	0.34 (0.14,0.83)	0.17 (0.09,0.33)	0.27 (0.11,0.66)	0.41 (0.06,2.97)	0.17 (0.05,0.56)
Regional Anesthesia	0.55 (0.22,1.34)	0.22 (0.1,0.48)	0.85 (0.21,3.46)	0.64 (0.26,1.57)	0.31 (0.16,0.59)	0.36 (0.15,0.9)	1.47 (0.2,10.64)	0.36 (0.11,1.15)
Spinal Anesthesia	0.5 (0.2,1.2)	0.24 (0.11,0.51)	0.73 (0.18,2.95)	0.98 (0.41,2.37)	0.2 (0.1,0.37)	0.23 (0.09,0.55)	2.84 (0.4,20.24)	0.37 (0.12,1.17)
Other Anesthesia	0.82 (0.31,2.17)	0.55 (0.23,1.31)	1.26 (0.28,5.62)	0.85 (0.32,2.26)	0.21 (0.09,0.5)	0.97 (0.37,2.55)	1.75 (0.22,13.85)	0.58 (0.16,2.16)
Unknown Anesthesia	NA	0.93 (0.27,3.21)	NA	0.98 (0.23,4.13)	NA	0.65 (0.13,3.38)	NA	0.54 (0.06,5.25)
Ascites	2.33 (2.09,2.6)	4.52 (4.25,4.8)	4.44 (4.03,4.88)	6.81 (6.48,7.16)	7.24 (6.86,7.64)	13.86 (13.36,14.38)	3.53 (3.12,4)	6.33 (5.72,7)
Bleeding disorders	2.2 (2.11,2.3)	1.46 (1.41,1.52)	2.38 (2.26,2.5)	3.58 (3.49,3.67)	3.83 (3.73,3.94)	4.99 (4.88,5.11)	1.6 (1.5,1.71)	3.12 (2.95,3.29)
Dialysis	2.37 (2.21,2.54)	1.51 (1.41,1.6)	2.01 (1.84,2.2)	3.1 (2.96,3.24)	4.41 (4.23,4.61)	5.56 (5.38,5.75)	0.98 (0.85,1.13)	0.82 (0.69,0.97)
Disseminated cancer	2.26 (2.13,2.41)	3.56 (3.43,3.69)	2.71 (2.54,2.9)	3.05 (2.93,3.17)	3.04 (2.91,3.17)	2.73 (2.62,2.83)	4.13 (3.87,4.41)	3.41 (3.17,3.68)
Dyspnea	2.51 (2.28,2.75)	2.37 (2.21,2.54)	4.56 (4.19,4.96)	9.8 (9.41,10.19)	9.78 (9.36,10.22)	19.83 (19.23,20.44)	3.07 (2.73,3.46)	5.62 (5.1,6.19)
At Rest								
Moderate Dyspnea	1.57 (1.5,1.63)	1.2 (1.16,1.25)	1.85 (1.77,1.94)	2.8 (2.73,2.87)	3.06 (2.98,3.15)	2.78 (2.71,2.85)	1.76 (1.67,1.86)	2.46 (2.33,2.59)
Emergency care	1.93 (1.86,2)	2.64 (2.58,2.7)	2.47 (2.38,2.56)	3.92 (3.84,4.01)	3.69 (3.61,3.78)	8.88 (8.73,9.04)	1.77 (1.68,1.85)	2.8 (2.68,2.93)
Functional health status prior surgery Independent	0.98 (0.78,1.24)	0.95 (0.81,1.12)	0.76 (0.6,0.97)	0.42 (0.37,0.47)	0.44 (0.38,0.5)	0.33 (0.29,0.36)	1.1 (0.78,1.53)	0.59 (0.45,0.77)
Functional health status prior surgery Partially	3.03 (2.39,3.84)	1.82 (1.54,2.16)	2.55 (1.99,3.27)	2.34 (2.08,2.64)	2.57 (2.24,2.94)	2.31 (2.08,2.58)	2.52 (1.79,3.56)	2.3 (1.74,3.04)
Functional health status prior surgery Totally Dependent	3.5 (2.74,4.47)	3.06 (2.57,3.65)	3.97 (3.07,5.12)	5.72 (5.07,6.46)	4.99 (4.35,5.74)	13.3 (11.95,14.81)	3.52 (2.47,5.01)	4.2 (3.16,5.58)
Congestive heart failure in 30 days before surgery	2.6 (2.38,2.85)	1.53 (1.41,1.66)	2.97 (2.69,3.28)	6.93 (6.64,7.23)	8.12 (7.77,8.49)	11.66 (11.28,12.07)	2.03 (1.77,2.33)	5.89 (5.38,6.44)
History of sever COPD	1.95 (1.86,2.04)	1.43 (1.37,1.48)	2.93 (2.79,3.07)	5.17 (5.04,5.29)	4.88 (4.75,5.01)	4.7 (4.59,4.81)	1.94 (1.82,2.06)	2.99 (2.83,3.17)
Systematic sepsis	2.17 (2.06,2.28)	2.65 (2.56,2.75)	2.42 (2.28,2.56)	4.93 (4.79,5.07)	4.38 (4.24,4.52)	7.81 (7.62,8.02)	2.13 (1.99,2.29)	3.36 (3.15,3.59)
SIRS								
Sepsis	4.2 (3.99,4.42)	6.63 (6.42,6.85)	4.06 (3.82,4.31)	6.4 (6.19,6.62)	6.5 (6.26,6.74)	14.22 (13.84,14.61)	2.56 (2.35,2.79)	5.6 (5.23,5.99)
Septic Shock	4.08 (3.71,4.49)	8.09 (7.66,8.54)	7.38 (6.77,8.04)	22.85 (21.99,23.75)	17.84 (17.06,18.66)	127.2 (123.31,131.21)	3.82 (3.34,4.37)	10.87 (9.92,11.93)
Acute renal failure (pre-op)	3.22 (2.87,3.6)	2.99 (2.75,3.26)	3.42 (3.01,3.89)	8.2 (7.76,8.67)	7.45 (7,7.94)	19.53 (18.77,20.32)	1.72 (1.39,2.12)	6.64 (5.9,7.46)
Steroid use for chronic condition	1.99 (1.89,2.1)	2.47 (2.39,2.56)	2.84 (2.69,3)	2.81 (2.72,2.91)	2.82 (2.71,2.92)	3.03 (2.95,3.13)	2.04 (1.9,2.19)	2.36 (2.19,2.53)
Transfusion >4 units PRBCs in 72 h before surgery	3.22 (2.97,3.5)	3.26 (3.07,3.46)	3.71 (3.4,4.06)	7.86 (7.54,8.18)	7.05 (6.73,7.39)	15.02 (14.56,15.5)	3.3 (2.96,3.68)	5.67 (5.18,6.21)
Ventilator dependent	3.04 (2.75,3.37)	4.82 (4.53,5.13)	5.43 (4.95,5.95)	20.08 (19.35,20.83)	12.36 (11.8,12.94)	117.32 (113.84,120.91)	3.96 (3.49,4.49)	8.95 (8.17,9.81)
Open wound/wound infection	5.27 (5.09,5.46)	1.98 (1.9,2.05)	3.88 (3.7,4.06)	3.49 (3.39,3.6)	3.76 (3.64,3.88)	5.24 (5.11,5.36)	1.34 (1.23,1.46)	3.49 (3.28,3.7)
>10% loss of body weight in last 6 months	2.48 (2.32,2.65)	4.17 (4.01,4.34)	2.91 (2.7,3.13)	4.5 (4.34,4.68)	4.65 (4.46,4.84)	4.24 (4.09,4.4)	2.8 (2.57,3.06)	3.55 (3.27,3.86)

^Zero inflated negative binomial regression was used to evaluate variable length of hospital stay measured in days.

Acute renal fail	CVA/Stroke with neurological defect	Cardiac arrest requiring	Myocardial infraction	Sepsis	Septic Shock	Return to OR	Died	Length of hospital stay (days)*
1.0431 (1.0418,1.0444)	1.0583 (1.0565,1.0601)	1.0517 (1.0502,1.0531)	1.0742 (1.0726,1.0759)	1.0132 (1.0127,1.0138)	1.0427 (1.0418,1.0435)	1.0158 (1.0154,1.0161)	1.07 (1.07,1.07)	1.0191 (1.019,1.019)
1.0108 (1.0086,1.013)	0.9703 (0.967,0.9735)	0.9798 (0.9773,0.9823)	0.9648 (0.9622,0.9674)	0.9888 (0.9877,0.9899)	0.9884 (0.9869,0.99)	0.9916 (0.9908,0.9923)	1.02 (1.01,1.014)	0.99 (0.99,0.99)
1.61 (1.42,1.83)	1.43 (1.22,1.67)	2 (1.8, 2.23)	1.37 (1.21,1.55)	1.92 (1.83,2.02)	2.18 (2.05,2.33)	1.68 (1.62,1.74)	0.93 (0.85,1.01)	1.74 (1.71,1.78)
0.93 (0.89,0.98)	0.9 (0.85,0.95)	0.79 (0.75,0.82)	0.86 (0.83 0.9)	0.84 (0.82,0.85)	0.76 (0.74,0.78)	0.86 (0.84,0.87)	1.09 (1.05,1.14)	0.855 (0.852,0.859)
1.05 (1.01, 1.1)	0.76 (0.72,0.81)	0.69 (0.66,0.73)	0.69 (0.66,0.73)	0.82 (0.81,0.84)	0.74 (0.72,0.76)	0.84 (0.83,0.86)	1.21 (1.15,1.26)	0.82 (0.817,0.824)
1.26 (1.19,1.34)	0.47 (0.42,0.52)	0.69 (0.64,0.73)	0.42 (0.39,0.46)	0.82 (0.8 0.84)	0.83 (0.8,0.86)	0.86 (0.84,0.88)	1.31 (1.22,1.41)	0.8 (0.795,0.804)
2.16 (2.08,2.23)	1.35 (1.29,1.42)	1.98 (1.91,2.05)	1.85 (1.79,1.92)	1.47 (1.45,1.5)	1.61 (1.57,1.65)	1.27 (1.26,1.28)	1.59 (1.56,1.63)	1.259 (1.255,1.263)
0.72 (0.67,0.78)	0.6 (0.54,0.67)	0.77 (0.71,0.84)	0.49 (0.45,0.54)	0.91 (0.88,0.94)	0.69 (0.66,0.73)	0.73 (0.71,0.75)	0.6 (0.57,0.63)	0.87 (0.869,0.879)
0.49 (0.45,0.53)	0.58 (0.51,0.66)	0.42 (0.38,0.46)	0.57 (0.51,0.63)	0.63 (0.61,0.65)	0.57 (0.54,0.6)	0.56 (0.55,0.58)	0.55 (0.52,0.58)	0.67 (0.666,0.676)
0.81 (0.63,1.04)	0.57 (0.42,0.76)	1.05 (0.78,1.4)	0.77 (0.57,1.04)	0.94 (0.84,1.05)	0.63 (0.55,0.73)	0.7 (0.65,0.76)	0.7 (0.6,0.8)	0.88 (0.86,0.89)
0.9 (0.78,1.04)	0.69 (0.58,0.83)	0.79 (0.69,0.91)	0.68 (0.58,0.79)	1 (0.94,1.06)	0.82 (0.75,0.9)	0.96 (0.92,1)	0.84 (0.77,0.92)	0.9 (0.89,0.91)
0.89 (0.8,0.98)	0.78 (0.69,0.89)	0.98 (0.89,1.09)	0.52 (0.47,0.58)	1.14 (1.09,1.19)	0.91 (0.85,0.97)	0.91 (0.89,0.94)	0.82 (0.77,0.87)	0.88 (0.87,0.89)
1.36 (1.31,1.42)	1.43 (1.36,1.51)	1.31 (1.25,1.37)	1.25 (1.2,1.31)	1.4 (1.38,1.43)	1.4 (1.36,1.44)	1.52 (1.5,1.54)	1.17 (1.14,1.2)	1.2 (1.19,1.2)
3.68 (3.53,3.83)	4.12 (3.9,4.34)	3.64 (3.49,3.8)	5.09 (4.86,5.33)	1.48 (1.46,1.51)	2.47 (2.41,2.53)	1.66 (1.64,1.68)	3.04 (2.98,3.11)	1.57 (1.569,1.578)
4.02 (3.84,4.21)	3.02 (2.83,3.22)	4.05 (3.86,4.24)	4.07 (3.88,4.27)	2.36 (2.3,2.42)	2.99 (2.9,3.09)	2.37 (2.32,2.41)	2.67 (2.57,2.78)	2.09 (2.08,2.1)
1.98 (1.88,2.08)	1.92 (1.8,2.05)	1.83 (1.74,1.93)	2.25 (2.14,2.37)	1.28 (1.24,1.31)	1.59 (1.54,1.64)	1.31 (1.29,1.34)	1.46 (1.41,1.52)	1.3 (1.29,1.31)
0.62 (0.24,1.59)	0.32 (0.12,0.86)	0.85 (0.26,2.78)	1.16 (0.42,3.22)	0.76 (0.44,1.3)	0.62 (0.31,1.24)	0.93 (0.66,1.32)	0.71 (0.38,1.33)	1.37 (1.22,1.53)
0.54 (0.22, 1.29)	0.3 (0.13,0.73)	0.82 (0.26,2.56)	0.59 (0.22,1.58)	0.82 (0.49,1.37)	0.73 (0.38,1.4)	0.74 (0.53,1.03)	0.76 (0.42,1.38)	1.09 (0.98,1.22)
0.11 (0.04,0.33)	0.14 (0.05,0.38)	0.31 (0.09,1.07)	0.18 (0.06,0.56)	0.12 (0.07,0.23)	0.09 (0.04,0.21)	1.01 (0.71,1.42)	0.38 (0.2,0.71)	0.25 (0.22,0.28)
0.18 (0.07,0.43)	0.25 (0.1,0.61)	0.49 (0.16,1.53)	0.55 (0.2,1.48)	0.26 (0.16,0.44)	0.15 (0.08,0.29)	0.49 (0.35,0.69)	0.41 (0.22,0.75)	0.47 (0.42,0.52)
0.11 (0.04,0.28)	0.17 (0.07,0.42)	0.3 (0.09,0.94)	0.2 (0.07,0.54)	0.13 (0.07,0.22)	0.13 (0.07,0.26)	0.85 (0.6,1.19)	0.41 (0.22,0.75)	0.26 (0.23,0.28)
0.23 (0.09,0.58)	0.63 (0.26,1.54)	0.6 (0.19,1.9)	0.68 (0.25,1.84)	0.26 (0.15,0.45)	0.17 (0.08,0.34)	0.63 (0.45,0.88)	0.43 (0.23,0.79)	0.76 (0.69,0.85)
0.2 (0.08,0.49)	0.2 (0.08,0.49)	0.41 (0.13,1.27)	0.66 (0.25,1.77)	0.28 (0.17,0.47)	0.16 (0.08,0.31)	0.41 (0.3,0.58)	0.46 (0.25,0.83)	0.95 (0.85,1.06)
0.35 (0.12,1.04)	0.31 (0.1,0.95)	0.52 (0.14,1.95)	0.39 (0.12,1.29)	0.37 (0.2,0.7)	0.21 (0.09,0.53)	0.77 (0.53,1.12)	0.5 (0.25,1.04)	0.61 (0.55,0.69)
NA	NA	NA	0.41 (0.05,3.66)	0.32 (0.09,1.12)	0.72 (0.22,2.37)	0.4 (0.19,0.83)	0.56 (0.18,1.76)	0.59 (0.49,0.7)
11.96 (11.14,12.84)	2.61 (2.18,3.12)	7.15 (6.53,7.83)	2.37 (2.04,2.75)	5.04 (4.79,5.3)	12.54 (11.96,13.14)	3.39 (3.25,3.54)	20.05 (19.3,20.83)	4.22 (4.14,4.3)
4.69 (4.49,4.9)	4.49 (4.23,4.75)	5.14 (4.91,5.37)	4.64 (4.43,4.85)	2.54 (2.47,2.61)	4.38 (4.25,4.51)	2.97 (2.92,3.02)	6.21 (6.06,6.36)	2.34 (2.33,2.36)
1.19 (1.04,1.35)	3.34 (3.01,3.7)	9.76 (9.25,10.3)	4.48 (4.17,4.82)	2.93 (2.81,3.05)	5.87 (5.63,6.12)	3.84 (3.74,3.94)	8.72 (8.44,9.01)	2.93 (2.9,2.96)
2.52 (2.33,2.73)	1.89 (1.69,2.12)	2.45 (2.26,2.66)	1.87 (1.71,2.05)	3.34 (3.23,3.45)	3.67 (3.52,3.84)	1.74 (1.69,1.79)	6.98 (6.78,7.2)	2.44 (2.42,2.47)
13.42 (12.6,14.29)	5.55 (4.95,6.23)	12.74 (11.92,13.61)	4.51 (4.07,4.99)	3.99 (3.8,4.19)	10.32 (9.85,10.8)	4.07 (3.94,4.21)	19.76 (19.09,20.44)	4.04 (3.98,4.1)
3.03 (2.89,3.17)	2.37 (2.22,2.52)	2.98 (2.84,3.13)	2.62 (2.5,2.75)	1.56 (1.52,1.6)	2.49 (2.42,2.57)	1.65 (1.62,1.68)	2.91 (2.84,2.99)	1.57 (1.56,1.58)
6.07 (5.86,6.29)	2.73 (2.58,2.88)	4.75 (4.57,4.93)	2.9 (2.78,3.02)	3.3 (3.24,3.36)	7.35 (7.18,7.52)	2.2 (2.17,2.23)	7.98 (7.82,8.14)	2.2 (2.19,2.21)
0.39 (0.32,0.49)	0.67 (0.47,0.95)	0.31 (0.25,0.38)	0.49 (0.39,0.62)	0.63 (0.56,0.72)	0.31 (0.27,0.35)	0.84 (0.77,0.93)	0.24 (0.21,0.26)	0.84 (0.82,0.86)
2.05 (1.65,2.56)	3.08 (2.16,4.38)	2.01 (1.64,2.47)	2.13 (1.68,2.71)	2.58 (2.28,2.92)	2.18 (1.91,2.47)	2.96 (2.69,3.26)	2.62 (2.36,2.91)	2.97 (2.89,3.04)
6.85 (5.49,8.54)	5.7 (3.99,8.16)	5.23 (4.25,6.43)	2.44 (1.89,3.14)	4.43 (3.9,5.04)	4.82 (4.22,5.49)	5.95 (5.4,6.55)	9.84 (8.85,10.94)	5.38 (5.22,5.53)
11.84 (11.13,12.59)	5.91 (5.32,6.57)	13.13 (12.35,13.96)	6.14 (5.65,6.67)	3.48 (3.31,3.66)	8.52 (8.13,8.93)	3.54 (3.42,3.67)	14.03 (13.54,14.53)	4.04 (3.98,4.1)
3.84 (3.66,4.03)	3.03 (2.83,3.24)	4.31 (4.11,4.52)	3.52 (3.34,3.7)	2.26 (2.2,2.32)	4.31 (4.18,4.44)	2.2 (2.16,2.25)	5 (4.88,5.13)	2 (1.99,2.01)
4.88 (4.62,5.16)	2.66 (2.45,2.88)	4.83 (4.57,5.1)	2.44 (2.28,2.61)	4.44 (4.32,4.56)	6.52 (6.3,6.76)	2.29 (2.24,2.34)	7.81 (7.59,8.04)	2.55 (2.53,2.57)
7.89 (7.44,8.37)	2.52 (2.26,2.82)	6.78 (6.36,7.22)	3.68 (3.41,3.97)	14.17 (13.84,14.5)	19.12 (18.54,19.72)	4.13 (4.04,4.23)	10.43 (10.09,10.77)	3.94 (3.9,3.98)
43.57 (41.32,45.94)	9.8 (8.79,10.94)	30.2 (28.42,32.08)	8.41 (7.65,9.25)	5.86 (5.53,6.21)	66.12 (63.74,68.59)	9.38 (9.07,9.7)	79.25 (76.66,81.94)	7.11 (6.98,7.24)
33.71 (31.85,35.67)	6.05 (5.24,6.98)	13.62 (12.56,14.77)	6.11 (5.44,6.86)	4.44 (4.17,4.74)	14.44 (13.7,15.22)	5.44 (5.21,5.67)	19.46 (18.63,20.32)	4.42 (4.32,4.52)
2.99 (2.82,3.18)	1.77 (1.61,1.95)	2.55 (2.38,2.72)	1.76 (1.63,1.9)	2.68 (2.6,2.76)	3.49 (3.37,3.62)	2.01 (1.97,2.06)	3.56 (3.44,3.67)	1.97 (1.95,1.98)
12.06 (11.35,12.82)	5.3 (4.75,5.92)	10.86 (10.17,11.6)	4.93 (4.5,5.41)	5.28 (5.06,5.51)	9.5 (9.08,9.93)	3.91 (3.78,4.04)	13.97 (13.49,14.46)	4.44 (4.38,4.51)
32.73 (31.07,34.47)	11.98 (10.9,13.17)	24.37 (22.98,25.84)	5.53 (4.97,6.15)	7.22 (6.89,7.56)	25.51 (24.53,26.54)	9.56 (9.26,9.87)	53.16 (51.48,54.9)	7.36 (7.23,7.51)
4.34 (4.13,4.57)	2.48 (2.29,2.69)	5.26 (5.01,5.52)	3.78 (3.58,3.99)	4.19 (4.09,4.3)	5.13 (4.97,5.29)	4.94 (4.86,5.02)	5.85 (5.7,6.01)	3.56 (3.53,3.58)
3.43 (3.17,3.7)	2.08 (1.83,2.36)	3.96 (3.67,4.27)	2.77 (2.54,3.03)	4.4 (4.25,4.55)	5.25 (5.03,5.48)	2.4 (2.33,2.47)	6.23 (6.01,6.46)	3.15 (3.11,3.18)

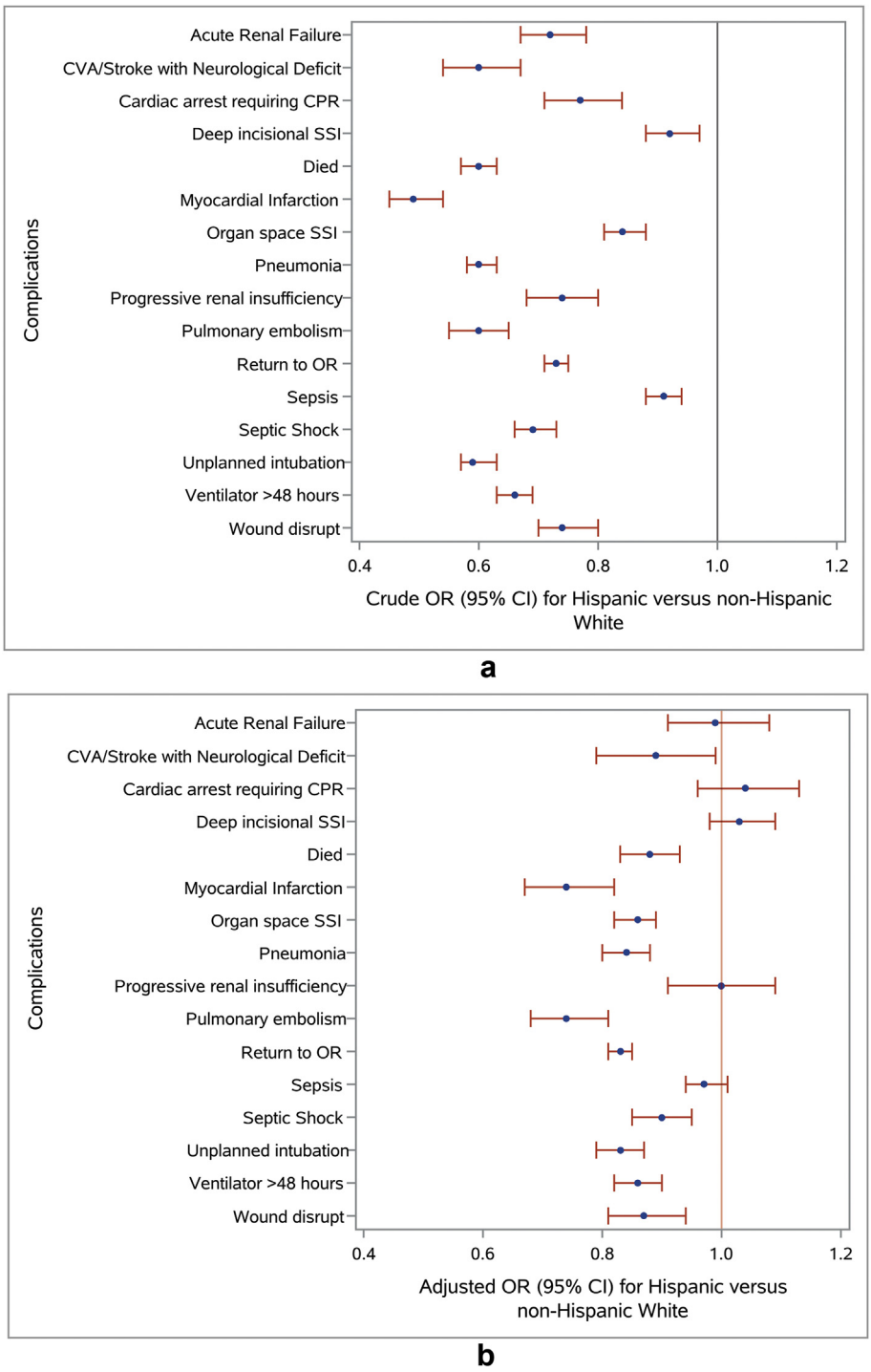

Fig. 1. Crude and adjusted odds ratios for postoperative outcomes by ethnicity: Hispanics vs non-Hispanic white.

Univariable analysis of post-operative complications

In the univariable logistic regression analyses we found that Hispanics had significantly lower odds of having any of the listed complications when compared to non-Hispanic White, non-Hispanic Black, and American Indian or Alaska Native, and in some of the outcomes when compared to non-Hispanic American Indian or Alaska Native (Table 3). Specifically, the odds of experiencing a complication in Hispanics compared to non-Hispanic White varied from as low as OR = 0.49 (95% CI: 0.45, 0.54) in postoperative myocardial infarction to OR = 0.92 (95% CI: 0.88, 0.97) in deep incisional SSI (Table 3, Fig. 1a). The odds of experiencing a complication in Hispanics compared to non-Hispanic Black varied from as low as OR = 0.42 (95% CI: 0.38, 0.46) in cardiac arrest requiring to OR = 0.84 (95% CI: 0.8, 0.8) in organ space SSI (Table 3, Fig. 2a). The odds of experiencing a complication in Hispanics compared to non-Hispanic American Indian or Alaska Native varied from as low as OR = 0.39 (95% CI: 0.33, 0.45) in pneumonia to OR = 0.88 (95% CI: 0.86, 0.89) length of stay (Table 3, Fig. 3a). The odds of experiencing a complication in Hispanics

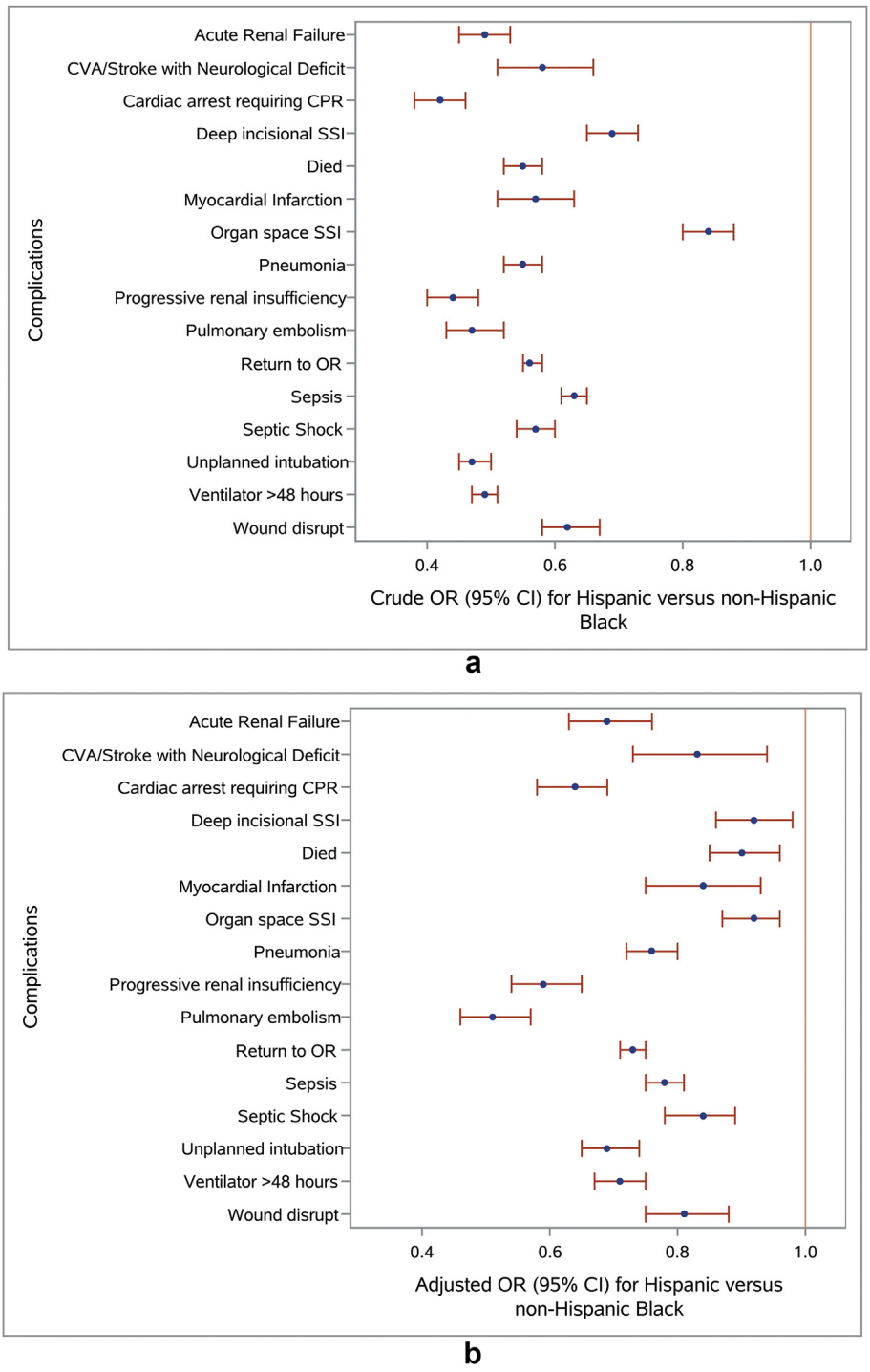

Fig. 2. Crude and adjusted odds ratios for postoperative outcomes by ethnicity: Hispanics vs non-Hispanic black.

compared to non-Hispanic Asian, Native Hawaiian, or Pacific Islander varied from as low as OR = 0.68 (95% CI: 0.58, 0.79) in myocardial infarction to OR = 1.5 (95% CI: 1.33, 1.68) in deep incisional SSI (Table 3, Fig. 4a).

Hispanics had significantly lower odds of postoperative mortality compared to non-Hispanic. Additionally, the rate of total length of hospital stay was lower in Hispanics than any other race/ethnic groups (Table 3).

Multivariable analysis of post-operative complications

Table 4A presents the adjusted OR and the corresponding 95% confidence intervals for race/ethnicity, BMI groups, and diabetes treatment variable. After controlling for the effect of age, gender, medicated hypertension, type of anesthesia, ascites, bleeding disorders, type of surgery, and all other covariates included in the regression models, compared to non-Hispanic White, prolonged length of stay was the only disparity found in Hispanics (RR = 1.01,

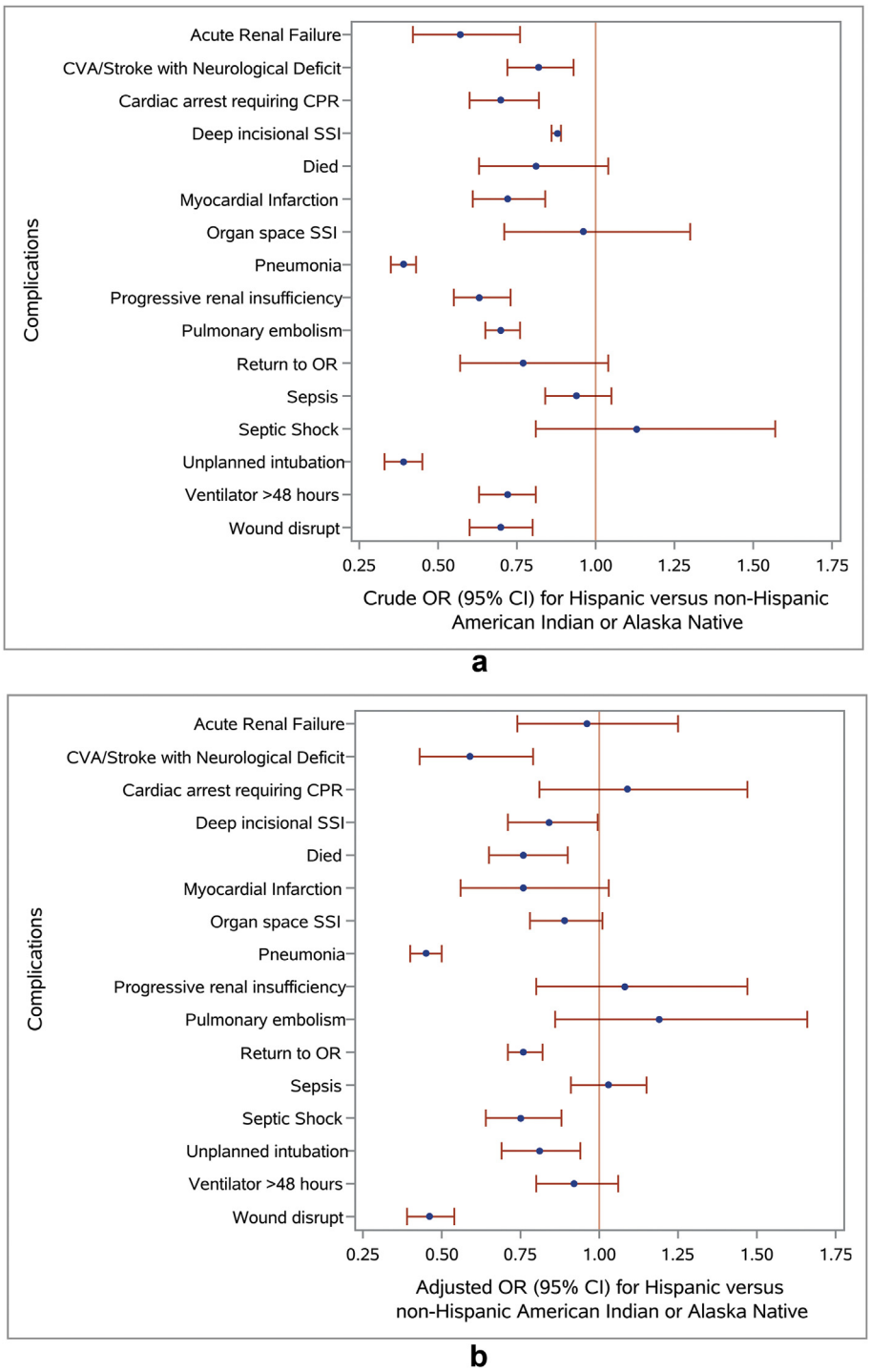

Fig. 3. Crude and adjusted odds ratios for postoperative outcomes by ethnicity: Hispanics vs non-Hispanic American Indian or Alaska native.

95% CI: 1.003, 1.014) (Table 4A, Fig. 1b).

Additional regression analyses were performed to explore this disparity. The rate ratio for Hispanics vs non-Hispanic White was very similar after adjusting for post-operative complications that may have influenced the length of hospital stay (RR = 1.02, 95% CI: 1.026, 1.016) (Table 4B). Analogous results were found when the analysis was performed in the subpopulation of patients with no known complications (RR = 1.019, 95% CI: 1.024, 1.013) (Table 4B).

Hispanics had significantly lower odds of experiencing all of the listed postoperative complications compared to non-Hispanic Black (Table 4A, Fig. 2b). The odds of experiencing a complication in Hispanics compared to non-Hispanic American Indian or Alaska Native were similar to univariable analyses and varied from as low as OR = 0.45 (95% CI: 0.4, 0.50) in pneumonia to OR = 0.981 (95% CI: 0.96, 0.99) in length of stay. (Table 4A, Fig. 3b). No difference was found in 8 of the listed complications (Table 4A). Hispanics compared to non-Hispanic Asian, Native Hawaiian, or Pacific Islander remained with significantly lower odds of experiencing majority of the postoperative complications except deep incision SSI (OR = 1.37, 95% CI: 1.21, 1.54), wound disruption (OR = 1.29, 95%

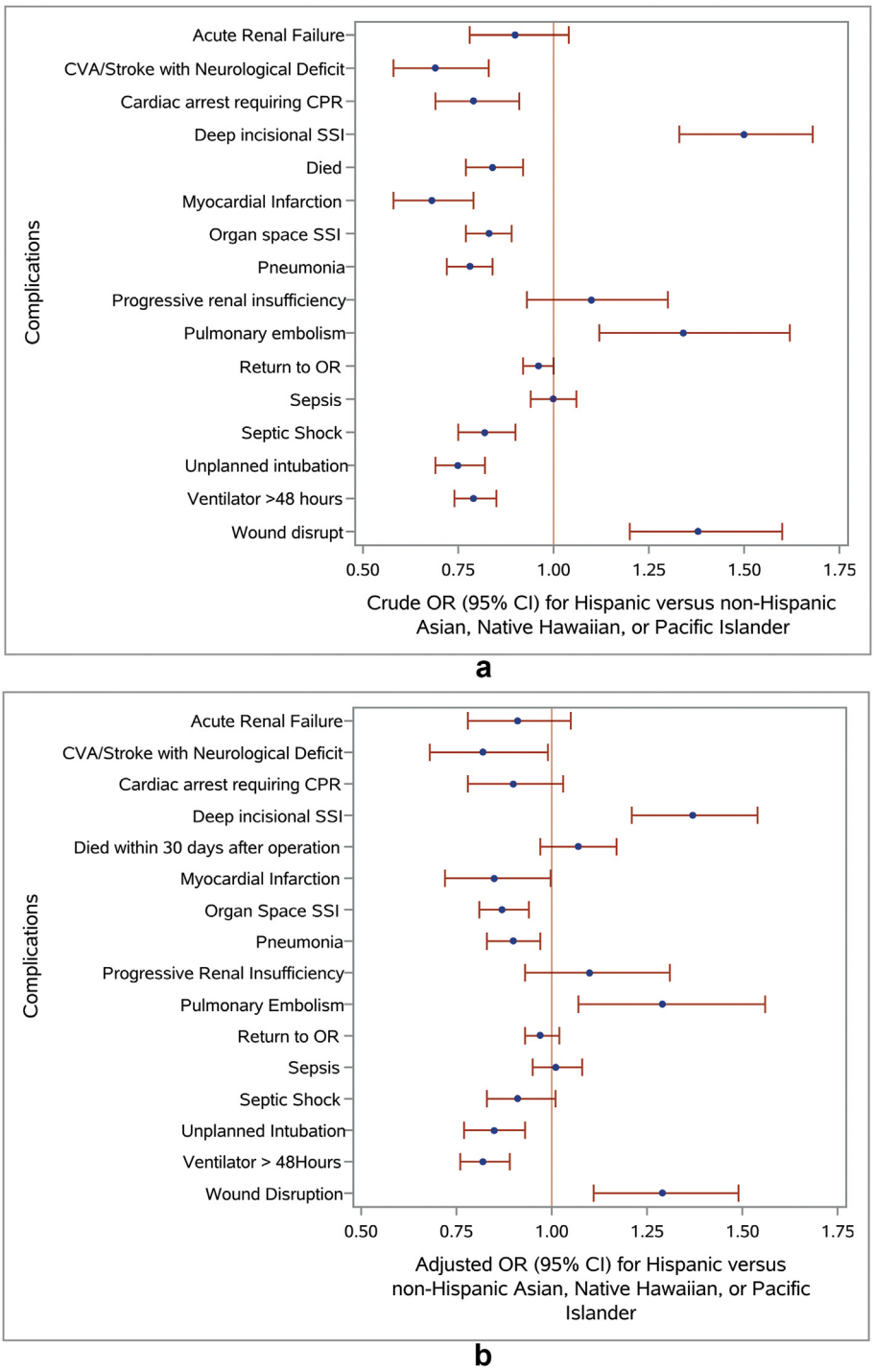

Fig. 4. Crude and adjusted odds ratios for postoperative outcomes by ethnicity: Hispanics vs Non-Hispanic Asian, native Hawaiian, or Pacific Islander.

CI: 1.11,1.49), and pulmonary embolism (OR = 1.29; 95% CI: 1.07,1.56). (Table 4A, Fig. 4b).

Overweight, obese and extremely obese individuals remained more likely than normal BMI individuals to experience deep incisional SSI, wound disruption, pulmonary embolism, and progressive renal insufficiency, controlling for the effect of the rest of the covariates included in the model (Table 3). In addition, obese patients were more likely than normal BMI patients to experience ventilator >48 h postoperative complication (OR = 1.08, 95% CI: 1.05, 1.11) and acute renal failure (OR = 1.22, 95% CI: 1.16, 1.29), controlling for the effect of all other covariates included in the model (Table 3). The odds of death within 30 days after operation remained higher for underweight compared to normal weight BMI patients (OR = 1.46, 95% CI: 1.37, 1.55) and lower in all overweight (OR = 0.77, 95% CI: 0.74, 0.79), obese (OR = 0.74, 95% CI: 0.71, 0.76), and extremely obese (OR = 0.88, 95% CI: 0.83, 0.92) patients when compared to normal BMI patients (Table 3).

In the multivariable regression analysis, the rate ratio of length of hospital stay in days changed to RR = 1.01 (95% CIL 1.003, 1.014) in Hispanics compared to non-Hispanic White and remained lower

Table 4A
Adjusted OR (95% CI) for Hispanic based on multivariable logistic regression models* for mortality and various major postoperative complications using the NSQIP data from 2007 to 2015.

Post-operative complication (outcome)	Hispanic vs White	Hispanic vs Black	Hispanic vs American Indian or Alaska Native	Hispanic vs Asian, Native Hawaiian, or Pacific Islander	Hispanic vs Unknown
Deep Incisional SSI	1.03 (0.98,1.09)	0.92 (0.86,0.98)	0.84 (0.71,0.995)	1.37 (1.21,1.54)	0.93 (0.87,0.996)
Organ Space SSI	0.86 (0.82,0.89)	0.92 (0.87,0.96)	0.89 (0.78,1.01)	0.87 (0.81,0.94)	0.9 (0.85,0.942)
Wound Disruption	0.87 (0.81,0.94)	0.81 (0.75,0.88)	0.46 (0.39,0.54)	1.29 (1.11,1.49)	0.92 (0.84,0.997)
Pneumonia	0.84 (0.8,0.88)	0.76 (0.72,0.80)	0.45 (0.4,0.50)	0.9 (0.83,0.97)	0.85 (0.8,0.896)
Unplanned Intubation	0.83 (0.79,0.87)	0.69 (0.65,0.74)	0.81 (0.69,0.94)	0.85 (0.77,0.93)	0.94 (0.88,0.997)
Ventilator > 48Hours	0.86 (0.82,0.90)	0.71 (0.67,0.75)	0.92 (0.8,1.06)	0.82 (0.76,0.89)	0.92 (0.87,0.978)
Pulmonary Embolism	0.74 (0.68,0.81)	0.51 (0.46,0.57)	1.19 (0.86,1.66)	1.29 (1.07,1.56)	0.83 (0.74,0.92)
Progressive Renal Insufficiency	1 (0.91,1.09)	0.59 (0.54,0.65)	1.08 (0.8,1.47)	1.1 (0.93,1.31)	0.91 (0.82,1.017)
Acute Renal Failure	0.99 (0.91,1.08)	0.69 (0.63,0.76)	0.96 (0.74,1.25)	0.91 (0.78,1.05)	0.97 (0.88,1.078)
CVA/Stroke with neurological deficit	0.89 (0.79,0.99)	0.83 (0.73,0.94)	0.59 (0.43,0.79)	0.82 (0.68,0.99)	0.96 (0.83,1.093)
Cardiac Arrest Requiring CPR	1.04 (0.96,1.13)	0.64 (0.58,0.69)	1.09 (0.81,1.47)	0.9 (0.78,1.03)	1.08 (0.97,1.2)
Myocardial Infarction	0.74 (0.67,0.82)	0.84 (0.75,0.93)	0.76 (0.56,1.03)	0.85 (0.72,0.997)	0.63 (0.56,0.7)
Sepsis	0.97 (0.94,1.01)	0.78 (0.75,0.81)	1.03 (0.91,1.15)	1.01 (0.95,1.08)	1.02 (0.98,1.07)
Septic Shock	0.9 (0.85,0.95)	0.84 (0.78,0.89)	0.75 (0.64,0.88)	0.91 (0.83,1.01)	0.91 (0.85,0.974)
Return to OR	0.83 (0.81,0.85)	0.73 (0.71,0.75)	0.76 (0.71,0.82)	0.97 (0.93,1.02)	0.9 (0.88,0.933)
Died within 30 days after operation	0.88 (0.83,0.93)	0.9 (0.85,0.96)	0.76 (0.65,0.90)	1.07 (0.97,1.17)	0.97 (0.91,1.04)

Abbreviations: OR (odds ratio); CI (confidence interval); NSQIP (National Surgical Quality Improvement Program).
*All multivariable logistic regression models included age, gender, surgery type, diabetes status, BMI, medicated hypertension, anesthesia type, bleeding disorders, dialysis, disseminated cancer, dyspnea, emergency care, functional health status prior surgery, congestive heart failure in 30 days before surgery, history of severe COPD, systematic sepsis, acute renal failure (pre-op), steroid use for chronic condition, transfusion >4 units PRBCs in 72 h before surgery, ventilator dependent, open wound/wound infection, and >10% loss of body weight in last 6 months.

in Hispanics compared to all other race/ethnicity groups (Table 4B). Odds of mortality within 30 days of operation remained significantly lower in Hispanics compared to non-Hispanic White (OR = 0.88 95% CI: 0.83, 0.93), non-Hispanic Black (OR = 0.9 95% CI: 0.85, 0.96), American Indian or Alaska Native (OR = 0.76 95% CI: 0.65, 0.90), and no difference between Hispanics and non-Hispanic Asian or Native Hawaiian was found (Table 4A).

To determine whether the protective effect seen in Hispanics was due to a disproportionate number of Hispanics undergoing fewer high-risk operations, we analyzed four surgery subtypes with the largest frequencies (general, gynecology, orthopedic, and vascular surgery). For those that underwent general surgery, Hispanics experienced significantly lower odds ratio for the majority of complications compared to non-Hispanic White OR = 0.68 (95% CI: 0.06, 0.77) in pulmonary embolism to OR = 1.08 (95% CI: 1.01, 1.16) in deep incisional SSI. Compared to non-Hispanic Black in the

Table 4B
Adjusted RR (95% CI) for Hispanics, based on multivariable zero-inflated negative binomial regressions models* for length of hospital stay using the NSQIP data from 2007 to 2015.

Post-operative complication (outcome)	Hispanic vs White	Hispanic vs Black	Hispanic vs American Indian or Alaska Native	Hispanic vs Asian, Native Hawaiian, or Pacific Islander	Hispanic vs Unknown
Length of hospital stay (days)*	1.01 (1.003, 1.014)	0.83 (0.82,0.83)	0.98 (0.96, 0.999)	0.97 (0.96, 0.98)	0.95 (0.95, 0.97)
Length of hospital stay**	1.02 (1.016, 1.026)	0.84 (0.84, 0.85)	1.00 (0.99, 1.02)	0.97 (0.97, 0.98)	0.96 (0.96, 0.97)
Length of hospital stay in patients with no known complications**	1.02 (1.013, 1.024)	0.85 (0.84, 0.85)	1.02 (1.00, 1.04)	0.99 (0.98, 0.99)	0.97 (0.97, 0.98)

Abbreviations: OR (odds ratio); CI (confidence interval); NSQIP (National Surgical Quality Improvement Program).
*Adjusted for age, gender, surgery type, and pre-operative conditions: diabetes status, BMI, medicated hypertension, anesthesia type, bleeding disorders, dialysis, disseminated cancer, dyspnea, emergency care, functional health status prior surgery, congestive heart failure in 30 days before surgery, history of severe COPD, systematic sepsis, acute renal failure (pre-op), steroid use for chronic condition, transfusion >4 units PRBCs in 72 h before surgery, ventilator dependent, open wound/wound infection, and >10% loss of body weight in last 6 months.
**Adjusted for age, gender, surgery type, and both pre-operative conditions and post-operative complications (deep incisional SSI, organ space SSI, wound disruption, pneumonia, unplanned intubation, ventilator > 48 h, pulmonary embolism, progressive renal insufficiency, acute renal failure, CVA/stroke with neurological deficit, cardiac arrest requiring CPR, myocardial infarction, sepsis, and septic shock).

Table 5
Adjusted OR (95% CI) for Hispanic for general, gynecology, orthopedics, and vascular surgeries based on multivariable logistic regression models* for mortality and various major postoperative complications using the NSQIP data from 2007 to 2015.

Post-operative complication (outcome)	Hispanic vs White	Hispanic vs Black	Hispanic vs Asian, Native Hawaiian, or Pacific Islander	Hispanic vs American Indian or Alaska Native	Hispanic vs Unknown
General Surgery					
Deep incision SSI	1.08 (1.01, 1.16)	1.02 (0.94, 1.11)	1.34 (1.16, 1.54)	0.86 (0.7, 1.05)	0.96 (0.88, 1.05)
Organ space SSI	0.86 (0.82, 0.9)	0.95 (0.9, 0.99)	0.85 (0.79, 0.92)	0.91 (0.79, 1.05)	0.88 (0.83, 0.93)
Wound disrupt	0.84 (0.77, 0.91)	0.79 (0.71, 0.87)	1.21 (1.02, 1.44)	0.48 (0.39, 0.58)	0.87 (0.78, 0.97)
Pneumonia	0.82 (0.77, 0.87)	0.71 (0.67, 0.76)	0.91 (0.83, 1.01)	0.38 (0.33, 0.43)	0.79 (0.74, 0.85)
Unplanned intubation	0.83 (0.78, 0.89)	0.69 (0.64, 0.74)	0.86 (0.77, 0.96)	0.73 (0.61, 0.87)	0.92 (0.85, 1)
Ventilator > 48 h	0.82 (0.77, 0.87)	0.68 (0.63, 0.72)	0.89 (0.81, 0.98)	0.84 (0.71, 0.99)	0.87 (0.81, 0.93)
Pulmonary embolism	0.68 (0.6, 0.77)	0.51 (0.45, 0.59)	1.41 (1.08, 1.83)	1.37 (0.85, 2.2)	0.77 (0.66, 0.9)
Progressive renal insufficiency	0.98 (0.87, 1.09)	0.54 (0.48, 0.61)	1.04 (0.84, 1.28)	0.92 (0.65, 1.31)	0.92 (0.8, 1.06)
Acute renal fail	1.02 (0.92, 1.14)	0.7 (0.62, 0.78)	0.97 (0.81, 1.17)	1.03 (0.74, 1.43)	0.98 (0.86, 1.12)
CVA/Stroke with neurological defect	0.98 (0.82, 1.17)	0.9 (0.73, 1.11)	0.87 (0.65, 1.16)	0.43 (0.29, 0.65)	1.2 (0.95, 1.52)
Cardiac arrest requiring	1.07 (0.96, 1.2)	0.62 (0.55, 0.7)	1.05 (0.86, 1.28)	1.01 (0.71, 1.44)	1.09 (0.94, 1.25)
Myocardial infraction	0.71 (0.62, 0.83)	0.72 (0.61, 0.85)	0.86 (0.68, 1.09)	0.67 (0.45, 1.01)	0.59 (0.5, 0.7)
Sepsis	0.98 (0.94, 1.02)	0.8 (0.76, 0.83)	1.08 (1.01, 1.17)	1.01 (0.89, 1.16)	1.04 (0.98, 1.09)
Septic Shock	0.87 (0.81, 0.92)	0.81 (0.75, 0.87)	0.89 (0.8, 0.99)	0.75 (0.63, 0.9)	0.89 (0.82, 0.96)
Return to OR	0.82 (0.79, 0.84)	0.74 (0.71, 0.77)	0.94 (0.89, 1)	0.72 (0.66, 0.79)	0.9 (0.87, 0.94)
Died	0.9 (0.84, 0.97)	0.89 (0.82, 0.96)	1.2 (1.06, 1.36)	0.75 (0.61, 0.91)	0.99 (0.91, 1.08)
Length of hospital stay (days)	1 (0.99, 1)	0.83 (0.83, 0.84)	0.98 (0.97, 0.99)	0.97 (0.95, 0.99)	0.99 (0.98, 1)
Gynecology Surgery					
Deep incision SSI	1.07 (0.82, 1.4)	0.95 (0.7, 1.29)	1.29 (0.71, 2.35)	0.68 (0.32, 1.42)	0.86 (0.62, 1.19)
Organ space SSI	1.1 (0.93, 1.29)	0.77 (0.64, 0.93)	1.07 (0.78, 1.47)	0.76 (0.45, 1.27)	1.23 (0.99, 1.52)
Wound disrupt	0.85 (0.65, 1.13)	0.75 (0.54, 1.03)	1.16 (0.62, 2.16)	0.23 (0.14, 0.39)	0.91 (0.64, 1.3)
Pneumonia	0.83 (0.61, 1.12)	0.61 (0.43, 0.86)	0.96 (0.53, 1.73)	1.73 (0.42, 7.19)	0.76 (0.52, 1.1)
Unplanned intubation	0.79 (0.52, 1.21)	0.52 (0.33, 0.83)	0.43 (0.23, 0.8)	N/A	1.04 (0.6, 1.8)
Ventilator > 48 h	1.51 (1.01, 2.25)	0.77 (0.49, 1.22)	0.74 (0.38, 1.45)	N/A	1.81 (1.02, 3.21)
Pulmonary embolism	0.58 (0.41, 0.81)	0.37 (0.25, 0.54)	0.87 (0.45, 1.68)	2.35 (0.32, 17.24)	0.72 (0.47, 1.09)
Progressive renal insufficiency	1.51 (0.95, 2.42)	0.81 (0.48, 1.39)	3.22 (0.75, 13.7)	N/A	3.01 (1.34, 6.8)
Acute renal fail	0.48 (0.17, 1.39)	0.3 (0.1, 0.93)	0.9 (0.1, 8.26)	N/A	0.59 (0.16, 2.17)
CVA/Stroke with neurological defect	0.87 (0.39, 1.94)	1.05 (0.37, 2.97)	0.96 (0.2, 4.72)	N/A	1.05 (0.36, 3.03)
Cardiac arrest requiring	1.4 (0.64, 3.07)	0.35 (0.16, 0.8)	0.44 (0.14, 1.39)	N/A	1.25 (0.44, 3.5)
Myocardial infraction	0.36 (0.14, 0.89)	0.3 (0.11, 0.82)	0.51 (0.12, 2.15)	N/A	0.3 (0.11, 0.82)
Sepsis	1.13 (0.93, 1.37)	0.68 (0.54, 0.84)	0.79 (0.57, 1.1)	0.9 (0.47, 1.74)	1.16 (0.9, 1.5)
Septic Shock	1.06 (0.69, 1.64)	0.95 (0.56, 1.62)	1.02 (0.45, 2.29)	1.63 (0.22, 12.05)	1.05 (0.6, 1.83)
Return to OR	0.81 (0.72, 0.92)	0.75 (0.64, 0.87)	0.88 (0.7, 1.11)	0.71 (0.47, 1.07)	0.97 (0.82, 1.14)
Died	1.08 (0.66, 1.77)	0.89 (0.49, 1.61)	0.88 (0.36, 2.16)	N/A	2.79 (1.25, 6.29)
Length of hospital stay (days)	1.13 (1.11, 1.14)	0.83 (0.82, 0.85)	0.97 (0.94, 0.99)	1.04 (0.98, 1.1)	0.95 (0.93, 0.97)

(*continued on next page*)

Table 5 (*continued*)

Post-operative complication (outcome)	Hispanic vs White	Hispanic vs Black	Hispanic vs Asian, Native Hawaiian, or Pacific Islander	Hispanic vs American Indian or Alaska Native	Hispanic vs Unknown
Orthopedics Surgery					
Deep incision SSI	0.88 (0.71, 1.08)	0.57 (0.45, 0.73)	1.45 (0.9, 2.33)	1.16 (0.6, 2.23)	0.89 (0.7, 1.14)
Organ space SSI	0.79 (0.62, 1)	0.68 (0.51, 0.9)	1.21 (0.74, 1.99)	0.82 (0.42, 1.59)	0.83 (0.63, 1.09)
Wound disrupt	0.86 (0.64, 1.17)	0.6 (0.42, 0.85)	1.34 (0.69, 2.59)	0.34 (0.19, 0.62)	1.02 (0.71, 1.46)
Pneumonia	0.8 (0.66, 0.98)	0.71 (0.56, 0.9)	0.75 (0.55, 1.04)	0.51 (0.31, 0.82)	0.86 (0.69, 1.07)
Unplanned intubation	0.83 (0.64, 1.08)	0.67 (0.49, 0.91)	0.79 (0.51, 1.23)	1.63 (0.59, 4.5)	1.25 (0.92, 1.71)
Ventilator > 48 h	1.04 (0.78, 1.39)	0.87 (0.61, 1.24)	0.95 (0.57, 1.59)	1.81 (0.56, 5.81)	1.37 (0.97, 1.94)
Pulmonary embolism	1.06 (0.87, 1.3)	0.55 (0.43, 0.69)	1.19 (0.79, 1.8)	1.02 (0.52, 2.02)	1.13 (0.89, 1.44)
Progressive renal insufficiency	1.15 (0.81, 1.63)	0.67 (0.44, 1.01)	1.34 (0.64, 2.8)	1.72 (0.41, 7.19)	0.98 (0.66, 1.47)
Acute renal fail	0.92 (0.6, 1.41)	0.76 (0.45, 1.27)	0.85 (0.39, 1.86)	0.74 (0.22, 2.49)	1.22 (0.73, 2.04)
CVA/Stroke with neurological defect	0.68 (0.42, 1.09)	0.6 (0.33, 1.07)	0.54 (0.27, 1.09)	0.72 (0.17, 3.12)	0.6 (0.36, 1.01)
Cardiac arrest requiring	0.81 (0.55, 1.19)	0.55 (0.35, 0.86)	0.57 (0.32, 1.02)	2.54 (0.35, 18.87)	1.1 (0.7, 1.74)
Myocardial infraction	0.66 (0.48, 0.9)	0.8 (0.54, 1.19)	0.97 (0.56, 1.68)	0.93 (0.33, 2.61)	0.57 (0.41, 0.8)
Sepsis	1.01 (0.84, 1.2)	0.77 (0.62, 0.96)	1.03 (0.74, 1.44)	1.02 (0.58, 1.77)	1.17 (0.94, 1.44)
Septic Shock	1.18 (0.86, 1.6)	0.82 (0.56, 1.2)	0.92 (0.53, 1.59)	0.45 (0.22, 0.94)	1.24 (0.86, 1.79)
Return to OR	0.82 (0.75, 0.9)	0.75 (0.66, 0.84)	1.06 (0.88, 1.27)	0.79 (0.6, 1.04)	1.02 (0.91, 1.14)
Died	0.77 (0.62, 0.96)	1.03 (0.76, 1.38)	1.04 (0.7, 1.53)	0.64 (0.33, 1.21)	1.08 (0.83, 1.39)
Length of hospital stay (days)	0.95 (0.94, 0.96)	0.81 (0.79, 0.82)	0.96 (0.93, 0.98)	0.87 (0.84, 0.91)	0.88 (0.87, 0.9)
Vascular Surgery					
Deep incision SSI	1.11 (0.94, 1.31)	0.89 (0.75, 1.07)	2.74 (1.7, 4.42)	1.05 (0.58, 1.9)	1.08 (0.87, 1.32)
Organ space SSI	1 (0.75, 1.32)	0.97 (0.71, 1.32)	1.2 (0.69, 2.11)	1.34 (0.42, 4.33)	1 (0.71, 1.43)
Wound disrupt	1.19 (0.98, 1.45)	1.07 (0.86, 1.33)	2.72 (1.56, 4.76)	1.01 (0.51, 2.01)	1.24 (0.96, 1.59)
Pneumonia	0.91 (0.79, 1.04)	0.96 (0.83, 1.12)	0.88 (0.7, 1.11)	0.69 (0.45, 1.07)	0.95 (0.81, 1.12)
Unplanned intubation	0.86 (0.75, 0.98)	0.76 (0.65, 0.88)	0.97 (0.77, 1.23)	0.85 (0.53, 1.36)	0.93 (0.79, 1.1)
Ventilator > 48 h	1.01 (0.89, 1.14)	0.85 (0.75, 0.97)	0.79 (0.65, 0.97)	1.02 (0.66, 1.58)	1.04 (0.9, 1.2)
Pulmonary embolism	1.13 (0.8, 1.58)	1.04 (0.7, 1.52)	1.59 (0.77, 3.31)	0.49 (0.19, 1.26)	1.05 (0.7, 1.59)
Progressive renal insufficiency	1.04 (0.82, 1.32)	0.74 (0.57, 0.96)	1.17 (0.73, 1.86)	0.75 (0.34, 1.63)	0.84 (0.64, 1.12)
Acute renal fail	1.18 (0.99, 1.42)	0.86 (0.71, 1.05)	1.16 (0.83, 1.63)	0.74 (0.41, 1.34)	1.03 (0.83, 1.28)
CVA/Stroke with neurological defect	0.82 (0.67, 1.02)	0.8 (0.64, 1.02)	0.97 (0.67, 1.41)	0.74 (0.37, 1.47)	0.85 (0.66, 1.09)
Cardiac arrest requiring	1.04 (0.87, 1.24)	0.73 (0.61, 0.89)	0.93 (0.68, 1.26)	0.87 (0.45, 1.66)	1.01 (0.81, 1.25)
Myocardial infraction	0.91 (0.77, 1.07)	1.19 (0.98, 1.45)	0.8 (0.61, 1.05)	0.76 (0.43, 1.35)	0.76 (0.62, 0.92)
Sepsis	0.94 (0.83, 1.07)	0.68 (0.59, 0.78)	0.92 (0.73, 1.16)	1.15 (0.69, 1.89)	0.91 (0.78, 1.06)
Septic Shock	0.87 (0.74, 1.03)	0.8 (0.66, 0.96)	1.15 (0.83, 1.58)	0.72 (0.41, 1.26)	0.81 (0.66, 0.99)
Return to OR	0.9 (0.85, 0.96)	0.72 (0.67, 0.77)	1.14 (1.01, 1.28)	0.9 (0.72, 1.12)	0.95 (0.88, 1.02)
Died	0.77 (0.68, 0.87)	0.91 (0.79, 1.05)	0.85 (0.68, 1.05)	0.61 (0.4, 0.93)	0.75 (0.65, 0.88)
Length of hospital stay (days)	1.11 (1.09, 1.13)	0.79 (0.77, 0.8)	1.02 (0.99, 1.06)	1.13 (1.05, 1.21)	0.89 (0.87, 0.91)

*All multivariable logistic regression models included age, gender, diabetes status, BMI, medicated hypertension, anesthesia type, bleeding disorders, dialysis, disseminated cancer, dyspnea, emergency care, functional health status prior surgery, congestive heart failure in 30 days before surgery, history of sever COPD, systematic sepsis, acute renal failure (post-op), steroid use for chronic condition, transfusion >4 units PRBCs in 72 h before surgery, ventilator dependent, open wound/wound infection, and >10% loss of body weight in last 6 months. ^Rate ratios (RR) and corresponding 95% CI were reported for variable Length of hospital stay.

general surgery category, Hispanics had significantly lower odds ratios for all but 2 complications (deep incisional SSI and stroke) where there was no difference. Hispanics had higher odds of deep incisional SSI, wound disruption, pulmonary embolism, sepsis, and mortality compared to non-Hispanic Asian or Pacific Islander (Table 5). Hispanic patients undergoing gynecological operations had lower odds of experiencing almost all complications compared to non-Hispanic Black patients but did not show a difference in odds ratios compared to other race/ethnicity groups. (Table 5). Similarly, for patients undergoing Orthopedics and Vascular surgeries, there were no differences found between Hispanics and other race/ethnic groups for most of the complications. (Table 5).

Discussion

We examined the effect of race and ethnicity on postoperative outcomes in approximately 3.5 million surgical cases using the NSQIP data from 2007 to 2015. While previous studies have been limited to the comparison of Whites and Blacks, this study included all available data for Hispanics, American Indians, Alaska Natives, Asians, Native Hawaiians, and Pacific Islanders. In this study, we addressed whether Hispanics have a higher risk of post-operative complications compared to other races/ethnicities that comprise the NSQIP datasets.

The findings in our study are unique as other studies have not found Hispanics to have a uniformly lower risk of postoperative complications compared to non-Hispanic Whites and non-Hispanic Blacks. Sukumar et al. reported Hispanic patients experienced no disparities relative to White patients for in-hospital mortality or overall postoperative complications but this study focused only on cancer surgical procedures.[10] Causey et al. reported a lower overall complication rate for Hispanics compared to non-Hispanic White and non-Hispanic Black after emergency surgeries, however, complication rates related to bowel obstruction and appendicitis were higher.[16] Studies investigating American Indian and Alaska Native surgical populations are limited and none have directly compared postoperative mortality or morbidity to Hispanics. Alvord et al. found that American Indians experienced a higher risk for 30-day all cause postoperative mortality but found no difference in postoperative morbidity compared to Caucasian patients.[24] In another study, NSQIP outcomes following emergency surgery indicated that complication and mortality rates for American Indian or Alaska Native patients varied depending on surgery type but overall rates were found to be higher than Hispanic patients.[16] In our study, after adjusting for covariates including surgery type, Hispanics had lower odds of experiencing 30-day mortality and the majority of the reported complications compared to American Indian or Alaska Native patients.

Based on our analysis, Hispanics compared to Asians experienced higher odds for 3 of the 17 outcomes and no difference was found in 7 of the remaining 14, including postoperative mortality. A previous study also found no difference in postoperative mortality between Hispanics and Asians but did find overall postoperative complication rate to be higher in Asian patients than Hispanic patients.[17]

In both the univariable and multivariable analysis, the highest odds ratios found in Hispanic patients correlated to surgical site infections. Hispanic ethnicity did not appear to have a positive effect on deep wound surgical site infections or organ space surgical site infections. Reasons for this outcome could not be assessed in this study.

There was a clear racial trend in relation to postoperative mortality. We found that Hispanics had lower odds of mortality compared to all other races. Additionally, Hispanics had crude and adjusted lower odds of postoperative myocardial infarction indicating factors associated with cardiac ischemia may be related to race. A meta-analysis done by Ruiz et al. reporting mortality outcomes among cardiac samples showed odds ratio for these studies was 0.75 or a 25% mortality advantage in the context of cardiovascular disease.[25] Hispanic ethnicity was also associated with lower odds of postoperative pneumonia, unplanned intubation, and ventilator use more than 48 h after surgery in both the univariable and multivariable analyses.

When we analyzed the four largest surgery subtypes separately, the findings in the general surgery category were very similar to the overall analysis of combined surgeries. The protective effect seen in Hispanics was insignificant for surgeries with smaller frequencies but this may have been related to insufficient power. Attempts to explain differences in racial/ethnic outcomes have been inconclusive and reasons for improved outcomes in Hispanics have yet to be identified.

Compared to non-Hispanic Whites, there was an observed disparity in length of hospital stay in Hispanics. Subsequent analyses on length of stay revealed that post-operative complications did not affect the rate ratio for this outcome and that race/ethnicity was independently associated with length of hospital stay. This is consistent with a previous finding that Hispanic ethnicity alone increased the odds of experiencing an extended length of stay (OR = 1.20, 95% CI: 1.10, 1.3).[26] Other studies show that extended hospital stay is only weakly correlated with inpatient complication rate.[27] Nonclinical factors such as limitations on discharge placement and insurance status do significantly lengthen hospital stay.[26,28–30] These variables could explain our findings but without insurance and payer data, we cannot confirm this.

Researchers have conventionally expected that for most populations, regardless of race or ethnicity, higher socioeconomic status generates better health outcomes.[31,32] In 1986, Kyriakos S. Markides and Jeannine Coreil suggested that unlike other socioeconomically disadvantaged minority groups, Mexican Americans were found to have better health outcomes in key health indicators such as infant mortality, life-expectancy, and mortality from cardiovascular disease. They concluded that Hispanic health outcomes are similar to whites although socioeconomically, the status of Hispanics is closer to that of blacks. They referred to this inconsistency as the Hispanic Epidemiological Paradox.[33] Since this initial publication, studies investigating health disparities in the United States have reported lower adult mortality risks among Hispanics than their non-Hispanic counterparts[33,34] and evidence of the Hispanic Paradox has been found in many aspects of medicine.[35–37] In this study, we find support for the Hispanic Epidemiological Paradox in surgical outcomes.

Understanding whether health disparities are primarily due to race, site of care, insurance status, or socioeconomics could help clinical leaders more effectively craft interventions to ameliorate differences in health outcomes. The results of the analysis of the ACS NSQIP database support the argument that biological factors may be responsible for the protective effect seen in Hispanics for virtually all complications in all surgery types. It is important to note that Hispanics in this dataset had a high proportion of overweight patients and high rate of type 2 diabetes that should have contributed to higher complication rates yet still observed lower odds of morbidity and mortality compared to all other races. Similarly, other authors have found high rates of cardiovascular risk factors in Hispanics that do not translate into higher rates of cardiovascular diseases.[35,38] This biological element could be related to a variety of interrelated factors including genetic variations associated with race, differences in immunological response, gut flora, or any combination thereof. The positive effect of Hispanic ethnicity appears to influence various risk factors affecting these patients. Interestingly, a recent study that compared epigenetic

rates of blood and saliva found that Hispanics have a lower intrinsic aging rate than Caucasians, implicating genetics as a plausible explanation for differences in health outcomes.[39] Furthermore, since all of the patients included in the NSQIP database were randomly selected from participating hospitals in the US, Canada, and even different continents, environmental factors are not likely the cause of our findings.

Additionally, the Hispanic Epidemiological Paradox may be related to the psychosocial and cultural aspects of the Hispanic population. Many studies have demonstrated the association between social and emotional support and better health outcomes including lower mortality rate and higher cancer survival.[40–42] The family-centered structure and a focus on family values in this culture provides the support individuals need to be resilient in the face of unfavorable health obstacles.[43]

There are some rebuttals for the Hispanic paradox. First, the "Healthy Migrant Effect" suggests migrants are healthier than those who do not migrate due to the arduous demands of migration. However, studies comparing US-born individuals, not subject to the healthy migrant effect, have found lower mortality rates in Hispanics compared to non-Hispanic Whites.[44] This hypothesis was not tested in our analyses as country of birth was not included as a NSQIP variable.

Secondly, the "Salmon Bias Hypothesis" states that Hispanic immigrants return to their country of origin after they retire from work, grow old, or develop a serious illness, thereby preventing those deaths from being reported in the U.S. mortality rate.[45] However, a study done by Abraido-Lanza et al. examined mortality rates in groups that faced barriers against return to their country of origin, including Puerto Ricans, and found that both groups had lower mortality rates than non-Hispanic Whites.[44] The authors concluded that the salmon bias hypothesis cannot explain the pattern of findings for lower mortality rates among Hispanics.[44] In this study, the confounding effect of the salmon bias was not able to be tested; however, all participants were followed postoperatively for the same 30 day period, excluding any salmon bias effect.

In respect to medical interventions and pharmacological therapies, this indicates that differences in outcomes, at least in part, may not be related to the therapy itself but are reflections of the effect of the Hispanic paradox. Furthermore, the Hispanic paradox may need to be taken into consideration in future medical intervention studies by adjusting the baseline of those individuals based on race or ethnicity. For example, a clinical trial incorporating a racially/ethnically mixed population will need to take into consideration the effect of the Hispanic Paradox and use an odds ratio adjustment to account for the differences in ethnic health outcomes.

This NSQIP database study has many strengths. The large sample size provided adequate power to be able to detect significant coefficient estimate for all covariates included in the models as well as enabled higher accuracy of the regression coefficient estimates. In addition, the study was conducted on data from both academic and community hospitals, data that have been independently validated and audited, and data pertaining to multiple preoperative variables. In spite of this, our study has some limitations. While we were able to control for comorbidities, the severity of the conditions (e.g. mild versus severe hypertension) were not captured by the NSQIP database. Differences in disease severity may be related to disparities seen in the non-Hispanic Black group as previous studies have demonstrated a racial disparity in hypertension and hypertension-related outcomes in black patients.[46] In the analysis, we were not able to control variables unavailable in the NSQIP database such as insurance status, socioeconomic status, surgeon volume, and hospital name or geographical location. These variables may have influenced outcomes and explained some of the disparities observed.

Conclusion

Given the current state of the literature and this particular analysis, there is mounting evidence of the Hispanic Paradox in the surgical realm. Factors explaining this phenomenon appear to include biological traits, psychosocial influences, and to a lesser extent, environmental factors. An increase in epidemiological and scientific studies in Hispanics is greatly needed to gain more understanding of the apparent protective factors influencing the Hispanic surgical population.

Summary

Data from the American College of Surgeons' National Surgical Quality Improvement Program from 2007 to 2015 was used to analyze surgical outcomes in approximately 3.5 million patients. Hispanics, in general, had lower odds of 30-day postoperative mortality and major morbidity compared to most of the races/ethnicities included in the ACS NSQIP database.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2018.10.004.

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