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Association Between Ethnicity and Prostate Cancer Outcomes Across Hospital and Surgeon Volume Groups

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Abstract

Objective—We analyzed the association between ethnicity and outcomes among prostate cancer patients across hospital and surgeon volume groups.

Methods—In this retrospective cohort study using SEER-Medicare databases for the period between 1995 and 2003, prostate cancer cases were identified and retrospectively followed for one year pre and up to eight years post-diagnosis. Based on volume, hospitals and surgeons were divided into three groups each. For each group, we fitted separate models to analyze the association between ethnicity and outcomes such as complications, eight year mortality and cost, adjusting for covariates. Poisson (zero-inflation), generalized linear model (log-link), and Cox regression models were used.

Results—African American ethnicity was associated with 30-day complications among medium volume hospital group. African American patients receiving care at medium volume hospitals and from medium volume surgeons had higher costs. Hispanic patients receiving care at low and medium volume hospitals had lower cost compared to white patients. Hispanic patients receiving care from a high volume surgeon experienced increased hazard of long-term mortality.

Conclusions—Association between ethnicity and outcomes varies across hospital and surgeon volume groups. Thus, volume based policy measures may need further exploration for understanding the interaction between structure, process, volume and outcomes.

Keywords

Hospital volume; surgeon volume; prostate cancer; cost; complications; mortality

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INTRODUCTION

Prostate cancer is the most common cancer diagnosis among men in the U.S [1] . A majority of these patients are diagnosed with localized stage. Radical prostatectomy is one of the common treatment options for localized prostate cancer. Disparities exist in the quality of prostate cancer care across regions, hospital settings, age and racial and ethnic groups [1–9]. Previous studies indicate that race and ethnicity are important predictors of treatment and outcomes for prostate cancer [1–5,7–9]. Understanding the determinants of ethnic and racial disparities in treatment, mortality, health resource utilization and cost is crucial for developing effective healthcare policies to improve quality of care of older prostate cancer patients [3,9].

Hospital and physician characteristics, particularly volume, play an important role in the variations in prostate cancer care outcomes such as cost, health resource utilization, complications and mortality [2–9]. Additionally, physician and hospital volume may influence the racial and ethnic disparity in prostate cancer care and outcomes [1–9]. Hospital and physician volume is often considered as surrogate for quality of care, and some researchers have suggested that referring (or redirecting) patients from low volume to high volume provider may improve quality and reduce health resource utilization and cost [6,9]. In men undergoing prostatectomy, the rates of postoperative and late urinary complications were lower for high volume hospitals and for surgeons who perform a higher number of such procedures [10–18]. Thus, hospital and surgeon volume can have implications for short and long term outcomes. In an earlier study, Ellison LM et al 2000 reported that hospital volume is inversely related to in-hospital mortality, length of stay and hospital charges for men receiving radical prostatectomy [11–12]. Later, using Medicare data, Hu JC et al 2003 reported that surgeon volume, but not the hospital volume, is inversely related to in-hospital complications and length of stay [15]. In a more recent study, Gooden KM, et al 2008 using Surveillance, Epidemiology, and End Results (SEER)-Medicare data reported that both hospital and physician volumes were not associated with reduced racial differences in recurrence-free survival after radical prostatectomy [13]. These studies are informative and our study aims to further addresses the issues such as racial and ethnic disparity in post-treatment complications and cost that were not addressed by these earlier studies. Such assessment can help us in better understanding the volume based policy measures so as to reduce the disparity in treatment, quality of care and outcomes. Hence, the objective of this study was to analyze the association between ethnicity and outcomes (complications, mortality and cost of care) across hospital and surgeon volume groups among elderly prostate cancer patients treated with radical prostatectomy using SEER-Medicare linked data. We hypothesized that older African American, Hispanic and white prostate cancer patients receiving surgery from a high volume hospital and a high volume surgeon will have lower complications, lower annual cost, and lower eight year mortality.

METHODS

Data sources and study sample

We developed a retrospective cohort design using the linked SEER-Medicare database for the period 1995 to 2003. All African American, Hispanic and white men, aged 66 years or older, diagnosed with prostate cancer (ICD codes: 185, 233.4, 236.5) between 1995 and 1998 and treated with radical prostatectomy as the primary treatment (n=7,950) were identified and followed retrospectively for one year prior to diagnosis and up to eight-years post-diagnosis. The SEER-Medicare linked database brings together Medicare administrative claims data and clinical tumor registry data for Medicare recipients, and offers an excellent opportunity for meaningful outcomes research in prostate cancer [19]. The SEER program collects data on cancer incidence, treatment and mortality in a representative sample of the US population and includes thirteen sites, encompassing wide geographic and population variation. The current SEER catchments area is estimated to include 14% of the US population. Cancer cases in SEER are primarily identified from hospital records. With the exception of individuals who are enrolled in HMOs or do not have Part B coverage, Medicare data provides information about all inpatient and outpatient utilization for residents of the US 65 years or older. Survival data was determined by Medicare vital statistics as well as SEER linkage to death certificates (National Death Index). The SEER-Medicare file contains one record for each Medicare beneficiary in the SEER program, integrating the individual's SEER and Medicare records [19]. The SEER-Medicare is a de-identified secondary database and released for public access for research purposes. The study was reviewed and approved by the institutional review board.

Of persons diagnosed with cancer at age 65 years or older and enrolled in SEER registries, 93% have been matched with their Medicare enrollment records, in a linked customized file-the Patient Entitlement and Diagnosis Summary File (PEDSF). In addition to diagnostic information, this file provides Medicare entitlement, utilization and census-tract and zip code based socioeconomic data. The SEER database provides characteristics of the tumor that are crucial to adequately adjust for prostate cancer severity, including histology, stage and grade. SEER also provides information on extent of disease that may have prognostic significance such as the size of the primary tumor and the extent and location of lymph node involvement. Men under 66 years of age at the time of diagnosis were excluded from our study to ensure that the data file included sufficient claims for medical care prior to diagnosis to allow for comorbidity adjustments. This also allowed us to assess the diagnostic procedures prior to cancer diagnosis. The lists of procedure codes, revenue center codes and service codes were reviewed to ensure that appropriate codes are used for each year, since HCPCS codes change over time.

Key dependent variables: Complications, Mortality, and Cost

The dependent variables for our analysis were mortality, complications and costs. All cause mortality was obtained from the vital status variable in Medicare claims data. In case the Medicare vital status variable was missing, the SEER death indicator in the PEDSF file was used. Time to death was calculated as the time between date of diagnosis and date of death, and for patients that were alive at the end of follow-up, the observations were censored. We identified complications that occur during either the index hospitalization or any other hospital admission, within 30 days of the date of radical prostatectomy treatment. Based on an earlier study by Alibhai et al (2005), we studied complications after radical prostatectomy for prostate cancer and grouped them into seven mutually exclusive categories: respiratory, cardiac, vascular, wound/bleeding, genitourinary, miscellaneous medical and surgical [20]. Direct medical care (DMC) costs were defined as the reimbursements received from Medicare by respective health care organization for period of one year post treatment [21]. The total DMC costs include costs of care provided by physicians and other health professionals, care provided in hospitals, outpatient and ER costs, inpatient medications, and laboratory services. The sources of cost data were: (1) Inpatient file-MEDPAR; (2) Hospital outpatient standard analytical file; (3) Physician part B file (claims for physician and other medical provider services); (4) home health agency; (5) durable medical equipment; and (6) hospice care.

Hospital and Surgeon volume

Data on hospital and surgeon volume were obtained from Medicare claims. Hospitals were classified as low, medium or high volume on the basis of their annual cumulative experience during the study period. For each hospital, the number of times radical prostatectomy was performed was tabulated for each year. We then divided each hospital into three groups based on tertiles: low (< 56), medium (57–103), and high (> 103). Similarly, surgeon volume was categorized as low (< 12), medium (13–27) and high (> 27) [6,10–18].

Covariates

Disease severity was adjusted for by using information on prostate cancer stage, grade and histology provided in SEER database. The Charlson comorbidity index was used to assess medical comorbidity using diagnostic information from Medicare claims for all encounters in the one year prior to cancer diagnosis to adjust for comorbidity, following the method outlined by Klabunde et al. [22–23]. We obtained demographic and income data from the PEDSF file.

Analytic Strategy

First, we tested for underlying difference in the demographic and clinical characteristics across ethnicity using t-tests and χ^2 tests as appropriate. Poisson regression models (with zero inflation correction) were used to assess the number of complication within 30-days of radical prostatectomy treatment. Separate models were fitted for each hospital and surgeon volume groups. The association between ethnicity and survival was analyzed using the Cox proportional hazard model. For all models, ethnic groups were key independent variable of interest. We fitted a generalized linear model (GLM) with a log-link and gamma distribution variance function [24] to study the association between ethnicity and cost. This approach uses log transformation to normalize the distribution of costs which is typically highly skewed and allows interpretation of the parameters directly on a dollar scale. All analyses were conducted using Statistical Analysis System (SAS), Version 9.2 (SAS Institute, Cary, NC).

RESULTS

The final analytic cohort consisted of 7,950 men diagnosed with prostate cancer during the study period 1995 to 1998 and followed retrospectively up to 2003. Overall, mean age at diagnosis was **69.9 years (SD=3.5)**, 6240 men were white, 862 were African American and 848 were Hispanic.

Comparisons of Demographic and Clinical Characteristics

Demographic and clinical attributes comparison between ethnic groups is presented in Table 1. Mean age of white patients was 69.9 years (SD=3.5), compared to 69.5 years (SD=3.4) for African American group and 69.7 (SD=3.4) for Hispanic group. White prostate cancer patients were more likely than others to receive care at high volume hospitals (25.26%) and from high volume surgeons (19.82%). African American patients were more likely to be from metro geographic area, have lower income and higher Charlson comorbidity score and less likely to be married, compared to other two groups. Histology was comparable between ethnic groups, whereas more number of African American and Hispanic patients had higher stage of diagnosis.

Association between ethnicity and complications

Table 2 displays the results of regression models examining the association between racial and ethnic groups and 30-day complications for each hospital and surgeon volume group. After adjusting for socio-demographic and clinical covariates, it was observed that African American patient receiving care at medium volume hospitals were more likely to have complications (Odds Ratio (OR)=1.39, 95% confidence interval (CI)=1.13, 1.62) compared to white patients. On the other hand, African American patients receiving care in low volume hospital (OR=0.81, CI=0.69, 0.95) were less likely to have complications compared to white patients. Also, African American patients receiving care from a medium volume surgeon had higher odds of complications (OR=1.23, CI=1.01, 1.46) compared to white patients. Thus, if 30-day complications are considered as one of the measure of quality of care, African American patients receiving care from a medium volume hospital and surgeon are more likely to experience poorer quality of care compared to white and Hispanic groups.

Association between ethnicity and mortality

As shown in Table 3, long-term mortality (up to eight years) was not associated with ethnic groups across all three hospital volume groups. However, Hispanic patients receiving care from a high volume surgeon had higher hazard of long-term mortality (Hazard ratio (HR) =2.11, CI=1.11, 3.99).

Association between ethnicity and cost

The results of regressions analyzing the association between ethnicity and costs are presented in Table 4. The GLM (log-link) models indicated that African Americans receiving care in medium volume hospitals had higher costs (OR=1.53, CI=1.32, 1.74) compared to white patients. Hispanic group receiving care in low (OR=0.78, CI=0.62, 0.94) and medium (OR=0.77, CI=0.12, 0.95) volume hospital had lower costs compared to white patients. African American patients had higher cost across all surgeon volume groups compared to white patients. Similar to hospital volume, Hispanic group was associated with lower cost for low (OR=0.67, CI=0.52, 0.85) and medium (0.84, CI=0.53, 0.95) volume surgeons compared to white patients.

DISCISSION

The association between ethnicity and outcomes differs across hospital and surgeon volume groups. As such, the objective of this study was to examine the association between ethnicity and complications, mortality and cost across three groups of hospital and surgeon volume. Important findings of the study are: (a) African American ethnicity was associated with 30-day complications for medium volume hospitals; (b) Hispanic patients receiving care from a high volume surgeon experienced increased hazard of long term mortality; (c) African American patients receiving care at medium volume hospitals and from medium volume surgeons had higher one year post-treatment costs; (d) Hispanic patients receiving care at low and medium volume hospitals had lower cost compared to white patients; and (e) Hispanic patients receiving care from low volume surgeons had lower cost compared to white patients. These results indicate that association between ethnicity and outcomes varies across hospital and physician volume. It is possible that other factors such geographic characteristics (location, neighborhood, rural/urban), patient characteristics (income, education, marital status), hospital characteristics (location, ownership, specialty, academic status, access to important clinical resources and competition), and physician characteristics such as training and process of care measures might contribute to the observed variation and thus need to be explored [6,9,25–47].

Hospital volume and surgeon volume have an impact on hospital and surgeon performance in terms of system operations, costs, and quality of care [48–53]. Research to date on the effects of hospital volume and ownership on variation in mortality, complications and health resource utilization has been inconclusive. Interactions between the hospital volume, quality of care and outcomes are less well understood and need to be addressed. Also, how these interactions affect the racial and ethnic disparity in quality of prostate cancer care remains to be explored. Maximizing adherence to quality measures was shown to be associated with improved mortality rates, independent of hospital or physician volume [27]. Possible factors associated with the disparity in treatment include discrimination in healthcare setting and uncertainty in clinical communication and decision-making [9]. At the same time, hospital characteristics such as volume, teaching status, location, size and ownership, influence differential treatment, quality of care and health resource utilization [48,51–53]. Among men undergoing prostatectomy, the rates of postoperative and late urinary complications were lower for high volume hospitals and for surgeons who perform a higher number of such procedures [10]. For radical prostatectomy, high-volume surgeons had half the complication risk and shorter length of stay compared with low-volume surgeons [10,13,15,17,25]. Prostate cancer patients receiving brachytherapy by high volume physicians had lower risk of recurrence, prostate cancer death but not for complications [29]. Thus, hospital and surgeon volume has implications for care provided to various racial and ethnic groups. Hospital volume may affect the relationship between hospitals and physicians, treatment of Medicare beneficiaries and finally, quality of care. Greater size, competition and increased complexity of disease have lead to reduction of many services in not-for profit hospitals [30–31,35–40,42–44,46–48].

Similar to other studies, characteristics of our study patients differ across ethnic groups. Medicaid enrollees, older, lower income and uninsured patients were less likely to receive care at high-volume hospitals after controlling for patients level characteristics [6,29]. A recent study using SEER-Medicare for seven SEER regions found that, hospital and physician volume was not associated with reduced racial differences in recurrence free survival post-surgery [13]. Our study continues this effort of exploring the association between ethnicity and outcomes as complications and cost, in addition to long term mortality and provider volume. Analyzing 30-day complications provides a short assessment of treatment outcome, while costs are robust indicators of health resource utilization. High surgeon volume was shown to be associated with lower inpatient cost and mortality for some surgical procedures [28,33,45,49–50]. On the other hand, in our study we found that African American patients receiving care at medium volume hospitals and from medium volume surgeons had higher one year post-treatment costs. Hispanic patients receiving care at low and medium volume hospitals had lower cost compared to white patients. Also, Hispanic patients receiving care from low volume surgeons had lower costs of care. Similar to our results, using national inpatient sample Trivedi et al (2006) reported that African American and Hispanics patients were more likely to receive cardiovascular procedures in low-volume hospitals; however, hospital volume did not explain large proportion of racial differences in post-procedure mortality [44]. In contrast to this, African American and Hispanic patients receiving lung resection in lower volume hospital were observed to have higher mortality [36]. Though many of the earlier studies have explored the relationship between surgical procedures volume and outcomes, fewer studies have addressed volume and outcomes relationship for medical conditions. A recent study using Medicare administrative data showed that admission to high-volume hospitals was associated with a reduction in mortality for acute myocardial infarction, heart failure, and pneumonia. However this association was not observed after certain threshold volume [41], indicating inverted “U” shape relationship between mortality and hospital outcomes for common medical conditions. Thus, these observations necessitate further exploration of the relationship between provider characteristics and outcomes [52–53].

Limitations

Despite the strengths of using population based national sample from SEER-Medicare, our study has certain limitations. The study cohort consisted of African American, Hispanic and white men over 66 years of age who lived in a SEER area and were not enrolled in a HMO. Our findings may not be generalizable to men under 66 years of age or to men enrolled in HMOs. The age and gender distribution for individuals 66 years and older in the SEER areas is comparable with that of the US elderly population. However, the SEER area distribution differs from that in the US elderly population in that SEER areas have a lower portion of whites and a higher concentration of persons of other racial and ethnic groups. While Medicare claims data provide excellent opportunity to analyze medical care in a broad population, these data have limitations such as misclassification of procedure codes as well as incomplete/incorrect surgeon and hospital characteristics. Also, we did not distinguish between open radical prostatectomy and laparoscopic prostatectomy procedures. For some prostatectomy patients, performing surgeon and hospital data was missing and thus volumes could not be calculated. Finally, there are indicators such as readmission, and length of stay that can be addressed. Our future studies will address these and other measures.

Conclusions

Our study findings have relevance for volume-outcome literature, particularly in analyzing the racial and ethnic disparity in mortality, complications and cost. We found that among patients receiving radical prostatectomy, the ethnicity-outcome association varied by volume group. The volume based arguments indicate a significant gain in overall quality of care if one redirects complicated surgery from low to high volume physician or hospitals. Many have called for implementation of such policy measures. However, arguments regarding appropriateness of such policies exist across both ends of the spectrum. Our results indicate that volume based policies may have to be tailored for a given outcome and ethnic group. Volume based policies encourage providers whose volumes are at threshold levels, to increase their operative numbers by operating on patients who may not previously have been considered candidates for surgery. Such policies may also affect patients' access to optimal care in rural areas. At hospitals where it may not be possible to perform specific operations, it may be difficult to attract or retain highly qualified or highly motivated surgeons as well as the other professionals. Additionally, volume based policies have many implications on process of care, health resource utilization and finally, cost and necessitates more accurate methods of defining volume [34]. If volume were the only measure of quality, referrals for selected non-emergency procedures might be focused on a smaller number of high volume hospitals. This might lead to improved economies of scale for these facilities, improved outcomes and lower costs. However, if volume is not a direct measure of quality across all racial ethnic groups, then, we need to understand the complex nature of hospital and surgeon volume, structure, process and quality of care paradigm. Thus, clear understanding of the association between hospital and physician volume and outcomes demands further research across different medical conditions that will aid clinicians and policy makers to identify strategies to improve quality of care.

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Table 1

Comparison of baseline demographic and clinical characteristics (n=7,950)

Variables	White (n=6640)	African American (n=862)	Hispanic (n=848)	P value
Mean age at diagnosis (SD)	69.9 (3.5)	69.5 (3.4)	69.7 (3.4)	0.0061
Hospital: Low (< 56)	49.85	58.76	69.60	<.0001
Medium (57–103)	24.89	17.52	14.66	
High (104–255)	25.26	23.72	15.74	
Surgeon: Low (< 12)	60.27	69.49	72.84	<.0001
Medium (13–27)	19.91	14.35	17.13	
High (28–163)	19.82	16.16	10.03	
Geographic Area (%) Metro	86.7	98.2	93.2	<.0001
Urban	11.7	1.8	6.5	
Rural	1.6	0.00	0.30	
Marital Status (%) Married	83.81	70.85	76.54	<.0001
Single	14.55	26.9	21.00	
Unknown	1.64	2.25	2.46	
Charlson comorbidity (%)- 0	88.67	79.31	97.84	<.0001
1–2	8.36	15.41	1.39	
> 3	2.97	5.29	0.77	
Mean annual median income of census tract (SD)	42736 (19431)	28034 (13235)	34267 (13412)	<.0001
Histology (%) In Situ/Distant	0.81	1.66	1.08	0.152
Localized/Regional	97.59	95.92	96.76	
Un-staged	1.60	2.42	2.16	
Tumor Size (%) ≤ T2a	17.99	17.55	19.91	0.0002
T2b and T2c	42.47	34.34	38.58	
≥ T3a	5.65	7.72	7.25	
Treatment (%):				
Radical Prostatectomy	78.19	77.79	78.86	0.73
Radical Prostatectomy +radiation	8.04	9.06	7.56	
Prostatectomy + radiation + hormone	2.98	3.78	3.24	
Prostatectomy + hormone	10.78	9.37	10.34	

Abbreviations: SD=Standard deviation

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Table 2

Association between hospital and physician volume and complication (n=7,950)

Covariates	Hospital			Surgeon		
	Low	Medium	High	Low	Medium	High
	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)
Ethnicity						
African American	0.81 (0.69, 0.95)	1.39 (1.13,1.62)	1.15 (0.96,1.33)	1.01 (0.87, 1.14)	1.23 (1.09, 1.46)	0.98 (0.76,1.20)
Hispanic	0.99 (0.86, 1.13)	1.15 (0.92,1.39)	1.12 (0.90,1.34)	1.05 (0.92, 1.18)	1.01 (0.78, 1.24)	1.02 (0.75,1.29)
White (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Age	1.05 (1.03, 1..07)	1.03 (1.01,1.04)	1.03 (1.02,1.05)	1.06 (1.04, 1.06)	1.02 (1.01, 1.04)	1.01 (0.99,1.03)
Income	0.99 (0.99, 0.99)	0.99 (0.99,0.99)	0.99 (0.99,0.99)	0.99 (0.99,0.99)	1.01 (1.0, 1.03)	1.01 (1.00, 1.03)
Married	0.94 (0.84, 1.05)	0.74 (0.66,0.89)	1.04 (0.90,1.18)	0.99 (0.89,1.08)	0.77 (0.62, 0.92)	0.93 (0.78,1.08)
TNM stage						
T2b –T2c	1.08 (0.98, 1.17)	1.04 (0.93,1.15)	0.98 (0.87,1.08)	1.12 (1.04, 1.20)	0.87 (0.74, 0.98)	1.06 (0.95,1.18)
≥ T3a	1.29 (1.15, 1.44)	0.81 (0.67,1.09)	0.91 (0.65,1.16)	1.26 (1.12, 1.40)	1.10 (0.76, 1.15)	0.77 (0.52,1.06)
≤ T2a (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Geographic area						
Metro	0.76 (0.59, 1.13)	1.04 (0.67,1.54)	1.22 (0.83, 1.61)	0.86 (0.53, 1.21)	0.85 (0.58, 1.28)	1.38 (0.89,1.86)
Urban	1.15 (0.76, 1.49)	1.12 (0.59,1.63)	1.43 (1.03, 1.84)	1.11 (0.86, 1.46)	1.06 (0.68, 1.50)	1.61 (0.89,1.11)
Rural (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Charlson comorbidity						
1–2	1.29 (1.15, 1.45)	1.21 (1.03,1.39)	1.24 (1.08,1.39)	1.39 (1.27, 1.51)	1.11 (0.92, 1.30)	1.22 (1.01,1.42)
>3	1.21 (0.95, 1.46)	1.22 (0.93,1.51)	1.26 (1.03,1.49)	1.35 (1.14, 1.55)	0.85 (0.51, 1.22)	1.46 (1.20,1.71)
(reference) 0	1.00	1.00	1.00	1.00	1.00	1.00

CI=confidence interval;

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Table 3

Association between hospital and physician volume and Mortality (n=7,950)

Covariates	Hospital			Surgeon		
	Low	Medium	High	Low	Medium	High
	Hazard ratio (CI)	Hazard ratio (CI)	Hazard ratio (CI)	Hazard ratio (CI)	Hazard ratio (CI)	Hazard ratio (CI)
Ethnicity						
African American	1.03 (0.82,1.29)	1.34 (0.83, 2.15)	0.90 (0.62,1.35)	1.14 (0.91, 1.43)	1.02 (0.63,1.64)	0.74 (0.45,1.16)
Hispanic	0.90 (0.71,1.15)	1.29 (0.83, 2.02)	1.31 (0.79,2.15)	0.95 (0.76, 1.19)	1.28 (0.77,2.10)	2.11 (1.11,3.99)
White (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Age	1.02 (1.01,1.04)	1.01 (0.98, 1.04)	0.99 (0.95,1.01)	1.02 (1.01, 1.04)	0.99 (0.96, 1.03)	0.99 (0.96,1.03)
Income	1.0 (1.0, 1.0)	1.00 (1.0, 1.0)	1.00 (1.0, 1.0)	1.00 (1.0, 1.0)	1.00 (1.0, 1.0)	1.00 (1.0,1.0)
Married	0.95 (0.81,1.11)	1.24 (0.91, 1.69)	1.03 (0.74,1.43)	0.99 (0.85, 1.16)	1.09 (0.79, 1.49)	0.91 (0.63,1.32)
TNM stage						
T2b –T2c	1.08 (0.93,1.27)	1.30 (1.02, 1.67)	1.07 (0.84,1.37)	1.11 (0.96, 1.27)	1.05 (0.79, 1.38)	1.27 (0.95,1.67)
≥ T3a	1.27 (1.03,1.55)	1.33 (0.89, 1.98)	1.26 (0.79,2.01)	1.37 (1.12, 1.68)	0.99 (0.66, 1.48)	1.15 (0.70,1.88)
≤ T2a (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Geographic area						
Metro	0.85 (0.46,1.56)	1.63 (0.39, 6.72)	0.81 (0.43,1.52)	0.87 (0.52, 1.47)	0.79 (0.32, 1.97)	1.20 (0.43,3.36)
Urban	0.93 (0.49,1.74)	2.34 (0.55, 9.85)	1.05 (0.53,2.09)	1.03 (0.59, 1.78)	0.93 (0.36, 2.36)	1.39 (0.48,4.08)
Rural (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Charlson comorbidity						
1–2	1.16 (0.89,1.52)	1.37 (0.87, 2.18)	1.00 (0.67,1.51)	1.16 (0.91, 1.49)	1.06 (0.69, 1.65)	1.27 (0.76,2.14)
>3	0.94 (0.61,1.44)	0.84 (0.39, 1.81)	1.14 (0.66,1.98)	0.98 (0.67, 1.45)	1.16 (0.58, 2.29)	0.81 (0.38,1.76)
(reference) 0	1.00	1.00	1.00	1.00	1.00	1.00

CI=Confidence interval

Table 4

Association between hospital and physician volume and Cost (n=7,950)

Covariates	Hospital			Surgeon		
	Low	Medium	High	Low	Medium	High
	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)	Odds ratio (CI)
Ethnicity						
African American	0.94 (0.77, 1.09)	1.53 (1.32,1.74)	0.99 (0.81,1.17)	1.09 (1.04, 1.24)	1.15 (1.02, 1.37)	1.03 (1.02, 1.23)
Hispanic	0.78 (0.62, 0.94)	0.77 (0.12,0.95)	0.85 (0.61,1.09)	0.67 (0.52, 0.85)	0.84 (0.53, 0.95)	0.97 (0.73, 1.21)
White (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Age	1.02 (1.01, 1.03)	1.01 (0.99,1.02)	0.97 (0.96,0.99)	1.01 (0.99, 1.02)	0.98 (0.97, 1.01)	0.99 (0.99,1.02)
Income	1.00 (1.00, 1.00)	1.00 (1.00, 1.00)	1.0 (1.0, 1.0)	1.00 (1.0, 1.0)	1.00 (1.0, 1.0)	1.00 (0.0,0.0)
Married	0.97 (0.86, 1.09)	0.96 (0.83,1.09)	0.93 (0.81,1.06)	0.98 (0.88,1.09)	0.98 (0.85, 1.13)	0.90 (0.76,1.03)
TNM stage						
T2b –T2c	0.99 (0.91,1.09)	1.09 (0.99, 1.19)	0.89 (0.80,0.98)	1.16 (1.07, 1.24)	0.76 (0.65,0.77)	0.91 (0.81,1.03)
≥ T3a	1.26 (1.09,1.43)	1.37 (1.15, 1.59)	1.26 (1.04,1.47)	1.48 (1.32, 1.64)	1.06 (0.84, 1.28)	0.98 (0.75,1.20)
≤ T2a (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Geographic area						
Metro	1.45 (1.09, 1.81)	1.56 (1.15, 1.97)	1.48 (1.14,1.76)	1.49 (1.18, 1.82)	1.26 (0.88, 1.65)	1.54 (1.18,1.91)
Urban	1.43 (1.07, 1.79)	1.39 (0.97, 1.83)	1.14 (0.89,1.47)	1.32 (1.01, 1.65)	1.13 (1.26, 1.52)	1.42 (1.03,1.79)
Rural (reference)	1.00	1.00	1.00	1.00	1.00	1.00
Charlson comorbidity						
1–2	1.67 (1.51, 1.83)	1.31 (1.14, 1.46)	1.33 (1.18,1.47)	1.45 (1.31, 1.57)	1.37 (1.19, 1.53)	1.66 (1.47,1.85)
> 3	1.25 (0.99, 1.51)	0.91 (0.65, 1.17)	1.44 (1.22,1.67)	1.16 (1.11, 1.95)	1.15 (0.86, 1.45)	1.74 (1.47,2.01)
(reference) 0	1.00	1.00	1.00	1.00	1.00	1.00

CI=confidence interval