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Differences in Physician Referral Drive Disparities in Surgical Intervention for Hepatocellular Carcinoma: A Retrospective Cohort Study

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STRUCTURED ABSTRACT

Objective—To determine whether sociodemographic and geographic factors are associated with referral for surgery and receipt of a recommended surgical intervention.

Summary—Surgical interventions confer significant survival advantages compared to palliative therapies for hepatocellular carcinoma (HCC), but there are disparities exist in use of surgical intervention. Few have investigated referral for surgery as a potential barrier to surgical intervention and little is known about the effects of patient geographic factors, including proximity to a surgical centers.

Methods—Data were abstracted from the Pennsylvania Cancer Registry for all patients diagnosed with HCC from 2006–2011. Using hospital procedure volume data from the Pennsylvania Health Care Cost Containment Council, we calculated proximity to a surgical center. We performed used multivariable logistic regression analyses to determine whether geographic, racial, socioeconomic, and clinical factors were associated with referral for surgery and receipt of a recommended surgical intervention.

Results—Of 3,576 patients with HCC, Approximately 41.0% of the 3,576 patients with HCC were referred for surgery. Patients who lived closer to a surgical center were less likely to be referred for surgery (Adjusted Odds Ratio [AOR]: 0.79, 95% confidence interval [CI]: 0.68–0.92). Surgical referral was less likely among older, male patients with Medicaid insurance and advanced tumor stage at diagnosis. Of those referred, 1,276 (87.0%) underwent a surgical intervention. Proximity to a surgical center was not associated with receipt of surgical intervention ($p=0.27$).

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Patients with distant tumor stage at diagnosis were less likely to receive recommended surgical intervention (AOR: 0.27, CI: 0.15–0.50).

Conclusions—Geographic and socioeconomic disparities in referral for surgery may be major barriers to surgical intervention for patients with HCC.

INTRODUCTION

Hepatocellular carcinoma (HCC) is the second most common cause of cancer death worldwide.¹ Although its incidence in the United States has more than tripled over the last 40 years, only modest improvements in survival have been made during that period.² Currently, only 15% of patients live for five years or longer³ and surgical interventions (radiofrequency ablation, resection or transplantation) are the only potentially curative treatment options.^{4–6} These interventions offer dramatic survival advantages over palliative therapies, but only 30–40% of patients with HCC actually receive such surgery.^{4, 7–9}

Though sociodemographic factors are associated with use of surgical interventions for HCC,^{8–14} referral for surgery may be the most significant barrier. Referral for surgical intervention is a key step in the process between diagnosis with HCC and receipt of surgical intervention but has not been well studied. One recent study considered referral for surgery as a secondary outcome but did not identify factors independently associated with this outcome.¹⁵ Others have tried to understand referral for surgery by studying referral to a specialist. While patients referred to specialists are more likely to receive some form of treatment for HCC, being seen by a specialist does not guarantee that an eligible patient will be offered a potentially curative surgery.^{16, 17}

There is also evidence that geographic location may impact referral for and use of surgical intervention for HCC. Use of surgical intervention can vary based on rural location (rurality) and region of residence.^{8, 12} Regional differences could be attributed to differences in proximity to specialized cancer care, which affects the use of specialized treatment approaches for other types of cancer.^{18–24} The relationship between geographic location and referral for surgery has not been explored, but there are significant regional differences in specialist consultation for HCC, which may partially influence referral for surgery.¹⁷

In summary, the literature points to some important gaps in our understanding of surgical intervention for HCC. Even though referral is a prerequisite for receipt of surgery, few studies distinguish between factors affecting referral for surgery and factors affecting receipt of a recommended surgical intervention. Similarly, geographic factors, including rural residence or proximity to specialized care, may contribute to variations in surgical intervention for HCC but have not yet been explored. Our study aims were to determine whether sociodemographic and geographic factors, including proximity to a surgical center and rurality, are associated with referral for surgery and receipt of a recommended surgical intervention for HCC.

METHODS

Design and Data sources

We conducted a retrospective cohort study using secondary data from the Pennsylvania Cancer Registry, Pennsylvania Health Care Cost Containment Council, and US Census Bureau. Pennsylvania Cancer Registry collects standardized information on all patients diagnosed with or treated for cancer in Pennsylvania and includes more than 95% of all new cancer cases. The Pennsylvania Health Care Cost Containment Council Database includes records from inpatient hospital visits at general acute care hospitals statewide and can be used to calculate hospital procedure volume. The US Census Bureau's 2011 American Community Survey includes information about educational attainment and median household income. The 2010 Census includes information about rurality, defined as the percent of the population in a ZIP Code Tabulation Area (ZCTA) that resides in a rural area.

¹ The University of Pittsburgh Institutional Review Board approved this as an exempt study.

Participants

We included patients ages 18 and older who were diagnosed with HCC between January 1, 2006 and December 31, 2011. During this period, there were no substantial changes to HCC treatment guidelines. At diagnosis, patients were residents of Pennsylvania or a geographically contiguous state. We excluded patients who were diagnosed with HCC at autopsy or using death certificates, had unknown treatment type or stage, or had contraindications for surgery in their Pennsylvania Cancer Registry record (e.g. based on age or comorbid conditions).

Study Outcomes

We used the Pennsylvania Cancer Registry to identify two outcomes: (1) referral for surgery for HCC and (2) receipt of surgical intervention. Surgical intervention was defined as liver resection, ablation, or transplantation. Because referral is a prerequisite for receiving surgery, patients in the latter analysis are a subset of those who were referred for surgery.

Variables

Our primary independent variables of interest were (1) proximity to a surgical center and (2) rurality. We defined proximity as residence within 30 minutes of a center that performed at least 30 liver cancer-directed procedures annually (top quintile of hospital procedure volume).^{25–28} Hospitals where 30 or more hepatic resections are performed have significantly less morbidity and mortality than lower volume hospitals.²⁵ Liver cancer-directed procedures were identified using Pennsylvania Health Care Cost Containment Council data and *International Classification of Diseases, Ninth Revision, Clinical Modification* procedure codes for liver resection, liver ablation, and liver transplantation. The twenty-six hospitals in Pennsylvania designated as surgical centers perform over 90% of liver cancer-directed procedures. These hospitals serve 19,000 to 326,000 patients each year and most are teaching hospitals located in large metropolitan areas. We then used

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¹Because ZIP codes refer to United States Postal Service mailing routes, the US Census Bureau created a geographic representation called the ZCTA, which identifies the areas in which a given ZIP code is most prevalent.

ArcGIS 10 (ESRI, Redlands, CA) to map the location of surgical centers and the residence of patients with HCC at time of diagnosis. Finally, we calculated travel time between the centroid of each patient's home ZIP code and the nearest surgical center. We defined rurality as a continuous measure describing the proportion of rural (versus urban) residential housing within a specified geographic area. In the current analysis, it is expressed as the proportion of residents in the patient's ZCTA living in rural areas according to 2010 Census data.

We also abstracted patient demographic data (including age, race, sex, and primary medical insurance at diagnosis) and National Cancer Institute Statistics, Epidemiology and End Results Program (SEER) summary stage at diagnosis for all patients with HCC. We used 5-year estimates from the 2011 American Community Survey to identify median household income and educational attainment for each patient's ZCTA.

Primary Analyses

We compared baseline patient characteristics for each outcome using the Wilcoxon rank sum test for continuous variables and chi-square or Fisher's exact tests for categorical variables. We used logistic regression to assess the univariable associations between all independent and control variables and referral for and receipt of surgical intervention for HCC. We used multivariable logistic regression models to determine whether sociodemographic and geographic factors, including rurality and proximity, were associated with referral for surgical intervention or receipt of surgical intervention. We decided *a priori* to adjust multivariable models for known confounders, including patient age, race, sex, tumor stage, insurance type, income and educational attainment. To address potential collinearity in our multivariable models, we used Pearson correlation coefficients to evaluate pairwise relationships between predictor variables. For pairs of highly correlated variables ($r > |0.5|$), we included in the multivariable model the predictor that was most strongly associated with the outcome variable. We derived odds ratios (ORs) and 95% confidence intervals (CIs) from univariable and multivariable logistic regression models, calculated variance inflation factors to identify further collinearity and evaluated all potential interactions between variables. We defined statistical significance as a two-tailed p-value of less than 0.05. All statistical analyses were performed using Stata 13 (StataCorp, College Station, TX).

Secondary Analyses

We conducted sensitivity analyses for variables that were excluded from multivariable models due to collinearity. We identified significant collinearity between proximity to a surgical center and rurality ($r = -0.51$) and between income and educational attainment ($r = 0.67$), so we included proximity and income in our multivariable models. We then conducted sensitivity analyses testing the effects of building the multivariable models using rurality instead of proximity to a surgical center or using educational attainment instead of income. We also identified determinants of proximity to a surgical center and rurality. We compared characteristics of patients living within 30 minutes of a surgical center with those living further away using the Wilcoxon rank sum test for continuous variables and chi-square test for categorical variables. Similarly, we identified factors associated with rurality

using Pearson's correlations for continuous variables, Wilcoxon rank-sum tests for binary variables, and Kruskal-Wallis tests for other categorical variables.

RESULTS

After identifying 4,560 case records for adults living in Pennsylvania or a contiguous state with a diagnosis of HCC in calendar years 2006 through 2011, we excluded patients with duplicate records (n=11), tumors of unknown stage (n=382), documented contraindications for surgery (n=361), or an uncertain course of treatment (n=230). The study cohort consisted of 3,576 unique patients with HCC. The mean patient age was 63.4 years (SD 11.5), 77.3% were male, and 71.7% were non-Hispanic Caucasian (Table 1).

A total of 1,466 (41.0%) patients were referred for surgery, of which 1,276 (87.0%) received a surgical intervention. The 190 patients who were referred but did not receive surgery either died before surgery could be performed (n=24), refused surgery (n=40), or did not undergo surgical intervention for unknown reasons (n=126).

Referral for Surgery

Patients referred (vs. not referred) for surgery were more often younger, Caucasian or Asian, and privately insured; they also had higher median income, educational attainment, and a greater frequency of localized disease (Table 2). In univariable analyses, patients living within 30 minutes of a surgical center were significantly less likely to be referred for surgical intervention than those living farther away (OR: 0.76, 95% CI: 0.66–0.87) (Table 2).

In our multivariable logistic regression model, proximity to a surgical center was independently associated with 21% lower odds of referral for surgery (adjusted OR: 0.79, 95% CI: 0.68–0.92) (Table 4). Older age, male sex, Medicaid or other insurance, and regional or distant tumor stage at diagnosis were associated with a decreased frequency of surgical referral. Asian race was positively associated with referral for surgery. There were no significant differences in referral based on African-American, Hispanic, or "Other/Unknown" race, Medicare insurance, or median household income. There were no significant interactions between predictor variables and referral for surgery, including interactions between race and proximity to a surgical center ($p>0.05$ for all potential interactions).

Receipt of Surgical Intervention

Patients who received surgical intervention (vs. not receiving surgery) were less likely to have an "Other/Unknown" race/ethnicity and to have distant involvement of HCC (Table 3). Our univariable logistic regression model revealed no significant differences in receipt of surgery based on proximity to a surgical center (OR: 0.84, 95% CI: 0.62–1.15). In our multivariable logistic regression model (Table 4), proximity to a surgical center was not significantly associated with receipt of surgical intervention (adjusted OR: 0.84, 95% CI: 0.60, 1.15). Distant stage at diagnosis was negatively associated with receipt of surgical intervention. There were no significant differences in receipt of surgery based on age, sex, African-American, Hispanic or Asian race/ethnicity, insurance type, or median household

income. In this analysis, there were no significant interactions between predictor variables and receipt of surgical intervention; potential interactions between race and proximity to a surgical center were non-significant ($p>0.05$ for all potential interactions).

Additional Analyses

Our sensitivity analyses were conducted to determine the effects of replacing proximity to a surgical center with rurality or replacing income with educational attainment in our multivariable models. There were no substantial changes to the multivariable model for referral for surgery after either substitution or to the multivariable model for receipt of surgery after substituting educational attainment for income. However, while we found no significant association between proximity to a surgical center and receipt of surgery, rurality was associated with a significantly increased likelihood of receipt of surgery (OR: 2.10, 95% CI: 1.10, 4.00).

Based on the results of our primary analyses, we identified factors associated with proximity to a surgical center and rurality. Patients who lived close to a surgical center were more often African-American or insured by Medicaid, and lived in ZCTAs with higher median incomes, lower educational attainment and decreased rurality (Table 5). There were no significant differences in proximity to a surgical center based on age, sex, or tumor stage. Rurality was negatively associated with African-American, Hispanic, or Asian race/ethnicity ($p<.001$), Medicaid insurance ($p<.001$), median household income ($p=.03$), and proximity to a surgical center ($p<.001$). There were no significant differences in rurality based on age ($p=.61$), sex ($p=.59$), tumor stage ($p=.11$), or educational attainment ($p=.31$).

DISCUSSION

In this retrospective cohort study of patients with hepatocellular carcinoma, we found that a number of non-clinical factors are associated with referral for surgery but that the vast majority of patients who were referred ultimately underwent surgical intervention. We also found that proximity to a surgical center was independently associated with decreased odds of referral for surgical intervention.

Our results suggest that socioeconomic and geographic disparities in surgical intervention tend to occur when patients are evaluated for treatment. The published literature offers weak explanations for this phenomenon. A few studies have identified disparities in referral to a specialist (defined as an oncologist or surgeon) after diagnosis with HCC,^{16, 17} but specialist referral only partially accounted for variations in treatment type; specialist referral is neither necessary nor sufficient for a patient to be referred for surgery. We demonstrate that almost every patient who is referred for surgery ultimately undergoes surgical intervention, which suggests that referral to a specialist is not the only underlying factor. Some suggest that comorbidities and age may influence a physician's choice of initial therapy for HCC, but our analysis excluded patients for whom documented contraindications to surgery existed. Referral for surgery is a result of both the physician's decision to recommend and the patient's decision to consider a potentially curative treatment. While racial and psychosocial disparities exist in refusal of HCC-directed surgery,¹⁵ we considered a patient to have been referred whether or not they declined to undergo surgical intervention. Unfortunately, few

studies have specifically evaluated referral for surgery, so much remains unknown about the barriers and facilitators of the referral process. Further studies are required to understand referral for surgery. It is conceivable that urban patients may be more likely to experience certain psychosocial issues such as healthcare mistrust and poor health literacy. This could impact their likelihood of having an established relationship with a physician and of being referred for surgical intervention. These psychosocial issues could be identified and addressed in order to improve surgical referral and ultimately patient outcomes.

Furthermore, our results suggest that geographic proximity to a surgical center may not translate into improved access to care. We could not control for rurality in our multivariable model (due to collinearity), but our secondary analysis revealed that proximity to a surgical center was a uniquely urban phenomenon. Urban residence has long been associated with low socioeconomic status and poor access to care, but we attempted to control for some of these factors using proxy measures of socioeconomic status. The fact that proximity to care is still independently associated with lower odds of referral for surgery suggests that there may be some unmeasured characteristics of urban patients that impede access to care. This idea is supported in part by the literature. For example, African-American patients tend to live in urban areas close to sources of healthcare, but report longer travel times than patients of other races.^{24, 28} This suggests that mode of transportation may be an important aspect of access to care for some urban patients, but not for their rural counterparts.

The findings in our study are consistent with the published literature in certain ways. For example, we identified many of the same socioeconomic disparities in referral for surgery as have previously been identified for overall utilization of surgery and found similar rates of surgery.^{8–14} However, when we excluded patients who were not referred for surgery from the analysis, we no longer identified socioeconomic disparities. The few studies that have separately considered referral for and receipt of surgery have focused on refusal of surgical intervention, which is associated with older age, African-American race, advanced tumor stage, and marital status.¹⁵ While our results differ, the previous study did not consider other reasons for which patients might not undergo surgery (e.g., patient preferences) and used data from 1985–2004, when different treatment options were available.

Other aspects of our results differ significantly from those found in the published literature. For example, disparities in surgery for African-American patients have been uniformly identified,^{8–14} but African-American race was not significantly associated with referral for or receipt of surgery in our study. We found significant racial variations in referral for surgery in our univariable analysis, but these differences were no longer apparent in the adjusted model. However, our secondary analysis revealed that African-American patients were more likely to live close to surgical centers than to live further away. This suggests that racial disparities in surgery might be better explained by geographic factors such as proximity to a surgical center. Still, the population of patients near surgical centers was still predominantly White and tended to have higher median incomes, so it is unlikely that proximity is solely a function of race or socioeconomic status.

We recognize that our study has some limitations. Most patients who were referred for surgery went on to undergo surgical intervention, so our analysis may not have had

sufficient power to identify significant differences in receipt of surgery. Income and educational attainment data were aggregated at the ZCTA level, which could obscure systematic differences from the population mean. However, it is common practice to abstract these data from the US Census when individual-level data are unavailable. Furthermore, because we used an administrative database, we could not identify patient-level factors, including detailed comorbidity information or laboratory or radiographic data to quantify the severity of a patient's underlying liver disease, which could impact the decision to refer a patient for surgery. Instead, we had to rely on a variable that indicated that a patient had documented contraindications to surgical intervention, which we hoped would include patients whose background liver disease precluded possible surgical intervention. We also could not identify delays in referral, which could affect patient outcomes. Finally, this analysis was conducted using data from patients in Pennsylvania and may not be generalizable to other geographic areas in the United States or to healthcare systems outside the US.

Our study builds on previous health disparities research in treatment for hepatocellular carcinoma. A commonly used conceptual framework defines three stages of health disparities research: (1) detection, (2) understanding, and (3) reducing disparities.²⁹ Our study addressed stage 2; we built upon the previous foundation of disparities research in HCC and aimed to further understand the underlying processes. Our findings suggest that future efforts to investigate disparities in HCC treatment may need to qualitatively assess barriers to surgical referral for urban populations and among physicians. Currently, surgical intervention offers patients with HCC the best chance at long-term survival, so it is important to identify barriers and design interventions to ensure broad, equitable access to potentially curative treatment for *all* eligible patients with HCC.

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Table 1**Baseline Characteristics of Patients with Hepatocellular Carcinoma**

Characteristics	All Patients (N=3,576)
<i>Demographic Characteristics</i>	
Age in years <i>Mean (SD)</i>	63.5 (11.5)
Male sex <i>N (%)</i>	2,765 (77.3)
Race <i>N (%)</i>	
White	2,565 (71.7)
African-American	653 (18.3)
Hispanic	120 (3.4)
Asian	163 (4.6)
Other/Unknown	75 (2.1)
Insurance Type <i>N (%)</i>	
Private	1,282 (35.9)
Medicare	1,522 (42.6)
Medicaid	470 (13.1)
Other	302 (8.4)
Income, \$1000s <i>Median (IQR)</i>	48.5 (37-64)
Percent high school graduates <i>Median (IQR)</i>	88.2 (83-92)
<i>Other Characteristics</i>	
SEER summary stage <i>N (%)</i>	
Localized	1,979 (55.3)
Regional	1,055 (29.5)
Distant	542 (15.2)
Proximity to high volume surgical center (<30 minutes) <i>N (%)</i>	2,230 (62.4)
Rural residence <i>Median (IQR)</i>	0.4 (0-19)

Abbreviations: IQR: interquartile range; N: number of patients; SD: standard deviation; SEER: National Cancer Institute Surveillance, Epidemiology and End Results program.

Table 2
Univariable Analyses of Factors Associated with Referral for Surgery for Hepatocellular Carcinoma

Characteristics	Referred (N=1,466)	Not Referred (N=2,110)	OR (95% CI)	P-Value*
<i>Demographic Characteristics</i>				
Age in years <i>Mean (SD)</i>	62.6 (11.2)	64.1 (11.6)	0.99 (0.98, 0.99)	<.001
Male sex <i>N (%)</i>	1,093 (74.6)	1,672 (79.2)	0.77 (0.66, 0.90)	.001
Race <i>N (%)</i>				<.001
White	1064 (72.6)	1501 (71.1)	1.00	--
African-American	234 (16.0)	419 (19.9)	0.79 (0.66, 0.94)	.009
Hispanic	40 (2.7)	80 (3.8)	0.71 (0.48, 1.04)	.078
Asian	88 (6.0)	75 (3.6)	1.66 (1.20, 2.27)	.002
Other/Unknown	40 (2.7)	35 (1.7)	1.61 (1.02, 2.55)	.042
Insurance type <i>N (%)</i>				<.001
Private	611 (41.7)	671 (31.8)	1.00	--
Medicare	597 (40.7)	925 (43.8)	0.71 (0.61, 0.82)	<.001
Medicaid	157 (10.7)	313 (14.8)	0.55 (0.44, 0.69)	<.001
Other	101 (6.9)	201 (9.5)	0.55 (0.42, 0.72)	<.001
Income, \$1000s <i>Median (IQR)</i>	50.3 (40-66)	46.8 (36-62)	1.01 (1.00, 1.01)	<.001
Percent high school graduates <i>Median (IQR)</i>	88.7 (84-92)	87.7 (82-91)	1.02 (1.01, 1.02)	.001
<i>Other Characteristics</i>				
SEER summary stage <i>N (%)</i>				<.001
Localized	1110 (75.7)	869 (41.2)	1.00	--
Regional	304 (20.7)	751 (35.6)	0.32 (0.27, 0.37)	<.001
Distant	52 (3.6)	490 (23.2)	0.08 (0.06, 0.11)	<.001
Proximity to high volume surgical center (<30 minutes) <i>N (%)</i>	858 (58.5)	1,372 (65.0)	0.76 (0.66, 0.87)	<.001
Rural residence <i>Median (IQR)</i>	0.8 (20.3)	0.6 (17.5)	1.23 (0.97, 1.57)	.087

Abbreviations: CI: confidence interval; IQR: Interquartile range; N: number of patients; OR: odds ratio; SD: standard deviation; SEER: National Cancer Institute Surveillance, Epidemiology and End Results program.

* P-values were calculated using univariable logistic regression analyses.

Table 3
Univariable Analyses of Factors Associated with Receipt of Surgery for Hepatocellular Carcinoma

Characteristics	Receipt of Surgery (N=1,276)	No Receipt of Surgery (N=190)	OR (95% CI)	P-Value*
<i>Demographic Characteristics</i>				
Age in years <i>Mean (SD)</i>	62.5 (11.2)	63.3 (11.2)	0.99 (0.98, 1.01)	.363
Male sex <i>N (%)</i>	943 (73.9)	150 (79.0)	0.76 (0.52, 1.09)	.137
Race <i>N (%)</i>				.052
White	927 (72.6)	137 (72.1)	1.00	--
African-American	203 (15.9)	31 (16.3)	0.97 (0.64, 1.47)	.878
Hispanic	33 (2.6)	7 (3.7)	0.70 (0.64, 1.47)	.396
Asian	83 (6.50)	5 (2.6)	2.45 (0.98, 6.16)	.056
Other/Unknown	30 (2.4)	10 (5.3)	0.44 (0.21, 0.93)	.031
Insurance type <i>N (%)</i>				.630
Private	531 (41.6)	80 (42.1)	1.00	--
Medicare	522 (40.9)	75 (39.5)	1.05 (0.75, 1.47)	.783
Medicaid	139 (10.9)	18 (9.5)	1.16 (0.68, 2.01)	.586
Other	84 (6.6)	17 (9.0)	0.74 (0.42, 1.32)	.312
Income, \$1000s <i>Median (IQR)</i>	50.3 (39-66)	50.1 (40-65)	1.00 (0.99, 1.01)	.677
Percent high school graduates <i>Median (IQR)</i>	89.0 (83-92)	88.1 (82-92)	1.01 (0.99, 1.03)	.393
<i>Other Characteristics</i>				
SEER summary stage <i>N (%)</i>				<.001
Localized	976 (76.5)	134 (70.5)	1.00	--
Regional	265 (20.8)	39 (20.5)	0.93 (0.64, 1.37)	.721
Distant	35 (2.7)	17 (9.0)	0.28 (0.15, 0.52)	<.001
Proximity to high volume surgical center (<30 minutes) <i>N (%)</i>	740 (58.0)	118 (62.1)	0.84 (0.62, 1.15)	.281
Rural residence <i>Median (IQR)</i>	0.9 (0-22)	0.3 (0-8)	1.82 (0.98, 3.36)	.058

Abbreviations: CI: confidence interval; IQR: Interquartile range; N: number of patients; OR: odds ratio; SD: standard deviation; SEER: National Cancer Institute Surveillance, Epidemiology and End Results program.

* P-values were calculated using univariable logistic regression analyses.

Multivariable Analyses of Factors Associated with Referral for & Receipt of Surgical Intervention for Hepatocellular Carcinoma

Table 4

Characteristics	Referral for Surgical Intervention		Receipt of Surgical Intervention	
	AOR (95% CI)	P-Value*	AOR (95% CI)	P-Value*
<i>Demographic Characteristics</i>				
Age in years	0.98 (0.98, 0.99)	<.001	0.99 (0.97, 1.00)	.127
Male sex	0.75 (0.63, 0.90)	.001	0.73 (0.50, 1.07)	.104
Race		.025		.038
White (Reference)	1.00	--	1.00	--
African-American	0.89 (0.73, 1.10)	.291	1.02 (0.64, 1.61)	.941
Hispanic	0.72 (0.47, 1.09)	.123	0.64 (0.27, 1.50)	.304
Asian	1.48 (1.05, 2.11)	.027	2.29 (0.90, 5.79)	.081
Other/Unknown	1.44 (0.87, 2.37)	.154	0.41 (0.19, 0.86)	.018
Insurance type		<.001		.508
Private (Reference)	1.00	--	1.00	--
Medicare	0.83 (0.69, 1.00)	.053	1.23 (0.84, 1.80)	.295
Medicaid	0.58 (0.46, 0.75)	<.001	1.29 (0.67, 2.11)	.538
Other	0.62 (0.46, 0.82)	.001	0.81 (0.45, 1.45)	.312
Income, \$1000s	1.00 (0.99, 1.01)	.125	1.00 (0.99, 1.01)	.708
<i>Other Characteristics</i>				
SEER summary stage		<.001		<.001
Localized (Reference)	1.00	--	1.00	--
Regional	0.32 (0.27, 0.38)	<.001	0.94 (0.64, 1.38)	.721
Distant	0.09 (0.06, 0.12)	<.001	0.27 (0.15, 0.50)	<.001
Proximity to high volume surgical center (<30 minutes)	0.79 (0.68, 0.92)	.002	0.83 (0.60, 1.15)	.273

Abbreviations: CI: confidence interval; AOR: adjusted odds ratio; SEER: National Cancer Institute Surveillance, Epidemiology and End Results program.

* P-values were calculated using multivariable logistic regression analyses. Educational attainment and rurality were not included due to multi-collinearity.

Table 5
 Characteristics of Patients with Hepatocellular Carcinoma, By Proximity to High Volume Surgical Center

Characteristics	<30 Minutes (N=2,230)	30 Minutes (N=1,346)	P-Value*
<i>Demographic Characteristics</i>			
Age in years <i>Mean (SD)</i>	63.5 (11.4)	63.5 (11.5)	.523
Male sex <i>N (%)</i>	1,726 (77.4)	1,039 (77.1)	.886
Race <i>N (%)</i>			<.001
White	1,431 (64.1)	1,134 (84.2)	
African-American	545 (24.4)	108 (8.0)	
Hispanic	89 (4.0)	31 (2.3)	
Asian	119 (5.3)	44 (3.3)	
Other/Unknown	46 (2.1)	29 (2.2)	
Insurance Type <i>N (%)</i>			<.001
Private	775 (34.8)	507 (37.7)	
Medicare	925 (41.5)	597 (44.4)	
Medicaid	345 (15.5)	125 (9.3)	
Other	185 (8.3)	117 (8.7)	
Income, \$1000s <i>Median (IQR)</i>	48.6 (35-65)	48.0 (41-62)	.002
Percent high school graduates <i>Median (IQR)</i>	88.0 (82-92)	88.3 (85-92)	.006
<i>Other Characteristics</i>			
SEER summary stage <i>N (%)</i>			.342
Localized	1,213 (54.4)	766 (56.9)	
Regional	672 (30.1)	383 (28.5)	
Distant	345 (15.5)	197 (14.6)	
Rural residence <i>Median (IQR)</i>	0 (0-1)	21.2 (5-52)	<.001

Abbreviations: 95% CI: 95% confidence interval; IQR: Interquartile range; N: number of patients; SD: standard deviation; SEER: National Cancer Institute Surveillance, Epidemiology and End Results program.

* P-values were calculated using Wilcoxon-Mann-Whitney and χ^2 tests.