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Racial and Socioeconomic Disparities in Access to Mechanical Revascularization Procedures for Acute Ischemic Stroke

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Abstract

Background—Mechanical revascularization procedures performed for treatment of acute ischemic stroke have increased in recent years. Data suggest association between operative volume and mortality rates. Understanding procedural allocation and patient access patterns is critical. Few studies have examined these demographics.

Methods—Data were collected from the 2008 Nationwide Inpatient Sample database. Patients hospitalized with ischemic stroke and the subset of individuals who underwent mechanical thrombectomy were characterized by race, payer source, population density, and median wealth of the patient's zip code. Demographic data among patients undergoing mechanical thrombectomy procedures were examined. Stroke admission demographics were analyzed according to thrombectomy volume at admitting centers and patient demographics assessed according to thrombectomy volume at treating centers.

Results—Significant allocation differences with respect to frequency of mechanical thrombectomy procedures among stroke patients existed according to race, expected payer, population density and wealth of the patient's zip code($p<0.0001$). White,Hispanic, Asian/Pacific Islander patients received endovascular treatment at higher rates than Black and Native American patients. Compared to White stroke patients, Black($p<0.001$), Hispanic($p<0.001$),Asian/Pacific Islander($p<0.001$) and Native American stroke patients(<0.001) all demonstrated decreased frequency of admission to hospitals performing mechanical thrombectomy procedures at high volumes. Among treated patients, Blacks($p=0.0876$), Hispanics($p=0.0335$), and Asian/Pacific Islanders($p<0.001$) demonstrated decreased frequency in mechanical thrombectomy procedures

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performed at high volume centers when compared to Whites. While present, socioeconomic disparities were not as consistent or pronounced as racial differences.

Conclusions—We demonstrate variances in endovascular acute stroke treatment allocation according to racial and socioeconomic factors in 2008. Efforts should be made to monitor and address potential disparities in treatment utilization.

Keywords

Racial Disparities; Socioeconomic Disparities; Acute stroke; Neurointerventional Procedures; Mortality; Thrombectomy

Introduction

The number of endovascular mechanical thrombectomy procedures performed for acute stroke in the United States has steadily increased.[1] Due to varied acceptance levels among medical professionals and requisition of substantial resources, only select facilities currently offer this treatment. While approved by the United States Food and Drug Administration, the procedure is not currently recognized as standard of care. Further, considerable equipment, infrastructure and technical requisites preclude universal accessibility. Thus, allocation and access to mechanical thrombectomy procedures varies considerably among medical centers and patients, respectively.

Differences in procedural utilization have been reported at the hospital level with respect to medical center size, teaching status, urban setting and geographic location. Improved outcomes have been demonstrated in facilities performing substantial volumes of mechanical thrombectomy procedures, independent of hospital characteristics.[2] Few published reports have examined demographic factors among treated populations.[1,3] This is the first study to evaluate racial and socioeconomic variations in the allocation of endovascular stroke procedures. We hypothesize that disparities may exist for patient access to endovascular stroke procedures and treatment at substantial volume centers. For our study, we have examined the same cohort used in a previous study to demonstrate improved outcomes at treatment centers with high mechanical thrombectomy volumes.[2]

Methods

Patient population

The National Inpatient Sample (NIS) hospital discharge database for 2008, a cross-sectional representation of 20% of inpatient admissions to US hospitals, was evaluated for study patient cohort and relevant variables. A cohort of inpatients with ischemic stroke, associated with ICD-9 codes 433, 434, 436, 437.0 and 437.1, were extracted. From this group, a subgroup of patients undergoing endovascular clot retrieval (ICD-9 procedure code 39.74: “endovascular removal of obstruction from the head and neck”) was evaluated using selection criteria previously described in Brinkiji et al. and Adamczyk et al.[2,3]

Statistical Analysis

National estimates were obtained by applying proper weights to variables as indicated in the Healthcare Cost and Utilization Project (HCUP)–NIS *Calculating NIS Variances Guide*.[4] All statistical analysis was performed using the SAS 9.3 software (SAS institute, Inc., Cary, NC).

1. Demographic data among stroke patients undergoing mechanical thrombectomy procedures—The populations extracted from the NIS database with ICD-9 codes representing ischemic stroke and treated by mechanical thrombectomy were evaluated for patient and regional demographics.

Patients with a diagnosis of ischemic stroke according to the above ICD-9 codes were examined. Individuals were stratified according to those who underwent mechanical thrombectomy and those who did not. Frequency of patients receiving the mechanical thrombectomy procedure (as a percentage of all stroke patients) was quantified according to race, socioeconomic classifications and population determinants All variables assessed were categorical.

The following characteristics were evaluated: race (RACE: White, Black, Hispanic, Asian/Pacific Islander, Native American, Other), expected payer (PAY1: Medicare, Medicaid, Private, Self-pay, No charge, Other), median wealth of the individual's zip code (ZIPINC_QTRL: $1-38,999, $39,000-47,999, $48,000-62,999, >$63,000), and population density where the patient resided (PL__NCHS2006: Central counties with >1 million population, Fringe counties with >1 million population, Counties with 250,000-999,999 population, Counties with 50,000-249,000 population, Micropolitan counties, Non-metropolitan or Micropolitan counties). Note that as coders were choosing between five races, “other” was chosen when patients did not conform to categories listed, including multiracial and patients with unknown race. Central counties represented metropolitan areas while fringe counties refer to suburbs.

Chi-square analysis was used to examine associations between these demographic variables and performance of mechanical thrombectomy procedures.

2. Stroke Admission Demographics to Centers with High Mechanical Thrombectomy Volume—Association between patient demographics and *admission to* substantial volume mechanical thrombectomy centers was examined. This analysis was performed for the entire cohort of stroke patients. Each center that performed mechanical thrombectomy procedures was categorized as “substantial volume” or “low volume” by the criteria previously described by Adamczyk et al.[2]. Hospitals that performed ≥10 procedures were classified as “substantial volume,” while those that performed < 10 procedures were classified as “low volume.”

Factors hypothesized to potentially affect treatment allocation in this dataset were included in the model as covariates, including gender and age. Univariate logistic regression was performed with procedural volume status of the center providing care as the dependant variable (<10 or ≥10). Independent variables assessed were race (RACE), expected payer

(PAY1), population density where the patient resided (PL__NCHS2006), and median wealth of the patient's zip code (ZIPINC_QTRL). Variables reaching statistical significance at 0.10 level in univariate analysis and those believed to be of relevance to the outcome were considered candidate variables for the multivariate model, and stepwise selection was used to determine the final multivariate model at 0.05 significance level

3. Patient Demographics According to Mechanical Thrombectomy Volume at Treating Centers—In order to assess for actual treatment disparities, an analysis similar to section 2 was performed for the subset of patients who underwent mechanical thrombectomy procedures. Association between patient demographics (race, expected payer, population density, median wealth of patient's zip code) and *treatment at* substantial volume thrombectomy centers was examined using the same analysis parameters stated above (univariate and multivariate models). Substantial and low volume centers were defined according to the criteria described in the prior analyses

Results

During the surveyed 2008 period, 2749 patients underwent mechanical thrombectomy procedures for acute stroke according to the NIS database. Endovascular clot retrieval was performed in the setting of acute stroke in 296 hospitals and was not performed in 5002 hospitals, as described in a prior publication.[2]

1. Demographic data among patients undergoing mechanical thrombectomy procedures

Demographic data among mechanical revascularization patients are presented in Table 1.

Significant allocation differences with respect to frequency of mechanical thrombectomy procedures existed by race among stroke patients ($p<0.001$ for all pairwise comparisons). The procedure was performed in 0.26% (1691/660212) of White patients, 0.18% (181/103156) of Black patients, 0.39% (70/17986) of Asian/Pacific Islander patients, 0.37% (176/47704) of Hispanic patients, and 0.17% (10/5848) of Native American patients. The procedure was performed in 0.31% (69/22028) of patients classified as “Other”.

Difference in procedure frequency was noted among stroke patients residing in regions of varying population density ($p<0.001$ for all pairwise comparisons). Mechanical revascularization was performed in 0.33% (955/285593) of patients residing in regions with > 1 million population, 0.28% (670/239645) of those residing in fringe counties with >1 million population, 0.15% (280/191121) in counties with 250,000 to 1 million, 0.25% (239/94941) in counties with 50k to 250k, 0.22% (306/140500) in Micropolitan counties and 0.21% (181/86682) in non-Micropolitan/metropolitan counties.

Significant differences were noted in procedure performance between all groups when evaluating median wealth of the individual's zip code ($p<0.001$ for all pairwise comparisons; except <$39,000 vs $39,000 to 47,999, $p= 1.000$). Mechanical revascularization was performed in 0.27% (824/301663) of patients residing in zip codes with mean wealth of < $39,000, 0.24% (722/301830) of those in zip codes with wealth of $39,000 to 47, 999,

0.22% (536/238059) of those in zip codes with wealth of $48,000 to 62,999 and 0.29% (604/201424) of those in zip codes with wealth ≥ $63,000.

Stroke patient's expected payer designation was associated with frequency of mechanical revascularization (p<0.001 for all pairwise comparisons). The procedure was performed in 0.19% (1463/765405) of Medicare patients, 0.40% (218/53991) of Medicaid patients, 0.44% (859/197102) of privately insured patients, 0.47% of self pay patients (142/29920), 0.15% (5/3190) of no charge patients and in 0.30% (62/21016) of patients whose expected payer was designated as “other”.

2. Stroke Admission Demographics to Centers with High Mechanical Thrombectomy Volume

Univariate and multivariate analyses examining associations between stroke patient demographics and *admission to* substantial volume mechanical thrombectomy centers are presented in Table 2. In multivariable analysis, age, gender, ethnicity, population density where the patient resided, median wealth of the patient's zip code and expected payer were independently associated with admission to substantial volume thrombectomy centers when adjusting for other covariates. Results are presented as (p value, odds ratio [confidence interval].

After adjusting for age, gender, population density, median wealth and expected payer, the frequency of being admitted to hospitals which performed mechanical thrombectomy procedures at high volumes was significantly lower in Black (<0.001, 0.616[0.600,0.633]), Hispanic (<0.001, 0.641[0.618,0.665]), Asian/Pacific Islander (<0.001, 0.621[0.585,0.659]) and Native American stroke patients (<0.001, 0.328[0.279,0.386]), when compared to White stroke patients.

After adjusting for all other covariates in the final multivariate model, those residing in fringe counties >1million, (p<0.001, 0.731[0.716,0.747]), counties with 250K to 1 million, (p<0.001, 0.329[0.320,0.338]), counties with 50K to 250K (p<0.001, 0.250[0.240,0.260]), Micropolitan counties (<0.001, 0.258[0.249,0.267]) and non-Micropolitan/metropolitan counties (<0.001, 0.352[0.339,0.365]) all demonstrated a decreased frequency in admission to hospitals which performed mechanical thrombectomy at high volumes when compared to stroke patients from central (metropolitan) counties with population > 1million,

When compared with stroke patients zip code with median wealth ≥ $63,000, patients residing in zip codes with lower median wealth demonstrated an increased frequency of admission to centers that performed high volumes of mechanical thrombectomy procedures (<$39,000/year, <0.001, 1.832[1.785,1.881]); $39,000 to 47,999, <0.001, 1.498[1.461,1.537]; $48,000 to 62,999 <0.001, 1.219[1.188,1.251]) after adjusting for all other covariates.

When compared to self pay stroke patients, those with expected Medicare, private insurance or “other” coverage demonstrated a decreased frequency of admission to centers that performed high volumes of mechanical thrombectomy procedures. (Medicare, <0.001, 0.828[0.791,0.866]; Private, <0.001, 0.893[0.854,0.935]; Other, p=0.036,

0.929[0.868,0.995]). Interestingly, Medicaid patients, when compared to self pay patients, demonstrated an even higher frequency of admission to centers that performed high volumes of mechanical thrombectomy procedures (<0.001, 1.065[1.012,1.120]).

3. Patient Demographics According to Mechanical Thrombectomy Volume at Treating Centers

Univariate and multivariate analyses examining associations between patient demographics and *treatment at* substantial volume mechanical thrombectomy centers are presented in Table 3. Results are presented as (p value, odds ratio [confidence interval])

After adjusting for all other factors in the final model, when compared to White patients, Black (0.0876, 0.717[0.489,1.050]), Hispanic (0.0335, 0.654[0.442,0.967]), and Asian/Pacific Islander patients (p<0.001, 0.205[0.120,0.350]) demonstrated a decreased frequency in mechanical thrombectomy procedures performed at high volume centers. Statistical testing approached, but did not reach significance when comparing Black patients to White patients (p=0.0876).

Those residing in counties with 250K to 1 million were the only group to demonstrate a statistically significant decreased frequency of mechanical thrombectomy procedures performed at high volume centers (p=0.025, 0.672[0.474,0.951]) when compared to patients from central counties with population > 1million.

When compared to patients residing in zip codes with the highest income (≥ $63,000), those from zip codes with the lowest income (< $39,000) demonstrated an increased frequency of mechanical thrombectomy procedures performed at high volume centers (p=0.0025, 1.656[1.195,2.297]).

When compared to self-pay patients, those with expected Medicare, Medicaid and private insurance coverage demonstrated an increased frequency of treatment at centers that performed high volumes of mechanical thrombectomy procedures. (Medicare, p=0.0002, 2.491[1.542,4.023]; Medicaid, p=0.0004, 2.788[1.575,4.934]; Private, p<0.001, 2.549[1.619,4.013].

Discussion

Endovascular mechanical revascularization procedures are offered for acute ischemic stroke at relatively few, specialized medical centers. Evaluation of the 2008 NIS database suggests improved stroke outcomes specifically in those centers with substantial mechanical thrombectomy volumes.[2] Hospital and individual level factors affecting patient access and treatment utilization are, therefore critical. Our group also previously found that geographic location and hospital characteristics are associated with allocation of mechanical thrombectomy procedures.[2] Further, physician influence and local transfer patterns likely impact access at an individual level. As race and socioeconomic factors harbor complex relationships with each of these determinants, we believed that potential disparities could exist for patient access to mechanical thrombectomy in the setting of acute stroke. We first examined procedural utilization frequencies with respect to race and socioeconomic

determinants. As prior studies demonstrate that facilities performing substantial volumes of mechanical revascularization procedures have more favorable patient mortality outcomes, we evaluated our data set for variances in access to substantial volume centers. We assessed *admission rates* at substantial volume facilities in a cohort of stroke patients and *treatment rates* at substantial volume centers in the subset of the stoke patients that underwent mechanical thrombectomy procedures.

Our analysis demonstrates an increased frequency of mechanical revascularization procedures performed in White, Hispanic and Asian/pacific island patients when compared to Blacks and Native Americans. The documented racial discrepancies appear paradoxical with respect to the increased overall ischemic stroke burden observed in minority populations. Higher stroke prevalence rates are reported in Hispanics (2.6%), Blacks (4.0%) and Native Americans (6.0%) when compared to Whites (2.3%).[5] Temporal trends over the past two decades suggest a growing inequality in stroke incidence among minorities.[6] Racial and ethnic minorities now constitute 28% of the population in the United States, with figures projected to nearly double by the year 2050.[7] While potential reasons for treatment differences are complex, these statistics underscore perceived racial-ethnic disparities.

When investigating allocation trends for mechanical revascularization procedures in the setting of acute stroke, it is critical to examine candidate suitability. Treatment targets acute stroke patients with large vessel occlusions presenting in a timely manner[8]. Relative differences in conventional stroke risk factors among Whites, Hispanics, and Blacks may contribute to treatment eligibility.[6] In the Northern Manhattan Stroke Study, Blacks and, to a lesser degree, Hispanics were found to have an increased prevalence of all ischemic stroke subtypes, with a disproportionally greater number of strokes secondary to intracranial disease and lacunar infarcts.[9] This epidemiological pattern would suggest a stronger predisposition for large vessel occlusions, potentially requiring endovascular treatment. Therefore, decreased utilization of mechanical thrombectomy procedures may relate to factors outside of stroke etiology. Our data set suggests a high frequency of mechanical thrombectomy procedures in Asian stroke patients. Data remain limited for ischemic stroke in U.S Asian populations, but international epidemiological data report symptomatic intracranial disease to be as high as 50%. This may reflect a greater predisposition for large vessel intracranial occlusions[10], a proportion of which could benefit from mechanical thrombectomy procedures.

Our data further reveal a decreased frequency of mechanical thrombectomy procedures performed at substantial volume centers among minorities receiving endovascular treatment. This apparent disparity may reflect issues of patient access. Evaluation of the entire cohort of stroke patients demonstrates that minorities are less likely to be admitted to centers performing substantial volumes of mechanical revascularization procedures, whether they are candidates for the therapy or not. Infrastructure and resources are needed to support an effective endovascular program capable of consistently performing mechanical thrombectomy procedures at a high level. Geographic and socioeconomic influences may preclude many patients from accessing substantial volume centers. In the future, regionalization of stroke facilities, patient diversion by paramedics and “hub and spoke” type stroke center models could potentially increase access for minority patients.

Disparities were most clearly evident, in all three of the above analyses, for Black patients. They underwent mechanical thrombectomy procedures at a lower frequency than Whites. Further, Black stroke patients were less likely to be admitted to facilities that performed substantial volumes of mechanical thrombectomy procedures. Among those treated, Black patients were less likely to undergo the procedure at substantial volume centers.

The discrepancy in allocation of endovascular stroke treatments among Blacks corresponds with other reported disparities in stroke care delivery for this patient population.[6,11] Published reports have demonstrated significant delays in stroke evaluation for Black individuals. Prolonged time intervals between 911call and arrival to the emergency department as well as latencies in performance of computed tomography head scans have been reported. Additionally, data from the National Hospital Ambulatory Medical Care Survey demonstrate that Black stroke patients have significantly longer wait times in the emergency department. These differences persist after adjustment for factors such as means of arrival, non-emergency triage, and hospital location.[12] Pre-hospital and Emergency Department delays are impactful, as the odds of receiving acute stroke treatment are time dependant. Even after adjusting for presentation times, Black stroke patients were less likely to receive intravenous thrombolytic treatment than Whites.[13] Data from the American Heart Association (AHA) sponsored “Get With The Guidelines–Stroke program”, indicate that Black stroke patients receive less evidenced-based care than hispanic or white patients.[14] These observations may contribute to the disparately high rates of stroke disability and mortality in Black patients. Potential caregiver racial biases, patient mistrust, educational and cultural barriers, and the relatively small number of minority physicians have been cited as potential reasons for these disparities.[6, 13]

Our data revealed potential population density and socioeconomic disparities as well. These differences were neither as consistent nor pronounced as the previously described racial variances. Patients residing in more heavily populated regions underwent mechanical thrombectomy procedures at a higher frequency than those living in less populated areas. Stroke patients living in densely populated cities were admitted to substantial volume mechanical thrombectomy centers at a higher frequency, even when compared to densely populated suburban areas. Endovascular stroke treatments require access to specialized centers with substantial resources and personnel, often located in large metropolitan regions. Future trends of this disparity should be monitored closely as additional hospitals seek to develop comprehensive stroke centers. Nonetheless, no significant treatment allocation differences were evident in the subset of patients undergoing mechanical thrombectomy procedures.

Patients residing in zip codes with the greatest median wealth had a higher incidence of endovascular treatment than those in less wealthy zip codes. However, stroke patients residing in zip codes with lower median wealth were admitted to substantial volume mechanical thrombectomy centers at higher frequency. Further, among stroke patients treated by mechanical thrombectomy, those residing in lower median wealth zipcodes had the greatest treatment frequency at substantial volume centers. Although somewhat unexpected, these variances suggest that patient populations with limited access to preventative healthcare and at highest risk for acute ischemic stroke may have suitable

access to substantial volume mechanical thrombectomy centers. This is noteworthy considering that socioeconomic status has been found to possess an inverse relationship with stroke incidence and mortality. Evidence suggests that patients living in poor areas have a higher incidence of severe ischemic strokes and a greater likelihood of long term disability.[15] Reasons for this association include higher prevalence rates of hypertension, smoking, diabetes, physical inactivity, and obesity in lower socioeconomic regions.

Treatment allocation can also vary according to payer designation. In our analysis, individuals insured by Medicare or Medicaid and “no charge” patients were less likely to receive endovascular thrombectomy procedures than self pay or privately insured patients. A similar pattern was previously reported for intravenous thrombolysis administration in the NIS data set.[16] Patterns of admissions and treatment allocation at substantial volume centers did not demonstrate such consistency. While stroke patients insured by Medicaid were admitted to substantial volume centers at higher frequencies than self-pay patients, privately insured and Medicare patients had lower admission rates. Nonetheless, Medicare, Medicaid and privately insured stroke patients all had higher mechanical thrombectomy treatment rates at substantial volume centers than did self-pay patients.

Multiple correlations between socioeconomic factors and access or treatment at high volume centers are highlighted in our analysis. Though we attempt to elucidate potential reasons for many of these findings, socioeconomic factors affecting treatment allocation and patient admission to high volume centers are likely influenced by a complex interplay between wealth, geography, population density and a variety of other confounding variables. Large-scale prospective case surveillance studies are needed to better evaluate potential socioeconomic disparities.

This study demonstrates disparities in endovascular stroke treatment at the population level. However, several limitations exist due to the retrospective nature of the analysis and inherent constraints in the Nationwide Inpatient Sample. Data provided in the NIS database remains subject to biases and recording error on those providing data such as race, where a large percentage of patients are classified as “other,” often when race is unknown. Information on stroke presentation and procedural selection algorythms remain unavailable. Another constraint was use of cross sectional data from 2008 alone to remain consistent with referenced studies. As the definition of “substantial volume” mechanical thrombectomy centers was derived from the 2008 Nationwide Inpatient Sample[2], we selected to analyze only data from that year. Although this constraint precludes longitudinal analysis, the paradigm maintains consistency of the source population. Further, it is quite possible that racial and socioeconomic trends could differ in a temporal fashion, and examining data from only one year can introduce bias. For example, it is reasonable to assume that the relatively low overall rates of mechanical thrombectomy among stroke patients will increase in the following years with increased experience and use of mechanical thrombectomy.

Disparities in health care allocation are pervasive. This study demonstrates variances in endovascular acute stroke treatment allocation according to racial factors. Socioeconomic influences are less clear. These finding parallel broad trends noted in stroke care. As

endovascular acute stroke treatment evolves and technology improves, continuous efforts should be made to monitor and address potential disparities in treatment utilization.

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Table 1

Demographic data among patients undergoing mechanical thrombectomy procedures

Frequency of mechanical thrombectomy -- with respect to race, population density, median wealth of zipcode, and expected payer -- among all stroke patients

Group	Thrombectomy procedures (% of stroke patients)	Pairwise p-value when compared to all other subgroups within category
Ethnicity		
White	1691 (0.26%)	<0.001
Black	181 (0.18%)	<0.001
Hispanic	176 (0.37%)	<0.001
Asian/Pacific Islander	70 (0.39%)	<0.001
Native American	10 (0.17%)	<0.001
other	69 (0.31%)	<0.001
Population Density		
Central counties with >1 million population	955 (0.33%)	<0.001
Fringe counties with >1million population	670 (0.28%)	<0.001
Counties with 250K to 1 million	280 (0.15%)	<0.001
Counties with 50K to 250K	239 (0.25%)	<0.001
Micropolitan counties	306 (0.22%)	<0.001
Non-micropolitan/metropolitan counties	181 (0.21%)	<0.001
Median wealth of zipcode		
< $39,000	824 (0.27%)	<0.001*
$39,000 to 47,999	722 (0.24%)	<0.001*
$48,000 to 62,999	536 (0.22%)	<0.001
≥ $63,000	604 (0.29%)	<0.001
Expected payer		
Medicare	1463 (0.19%)	<0.001
Medicaid	218 (0.40%)	<0.001
Private	859 (0.44%)	<0.001
Self-pay	142 (0.47%)	<0.001
No charge	5 (0.15%)	<0.001
Other	62 (0.30%)	<0.001

*: <$39,000 vs $39,000 to 47,999, p= 1.000

Table 2

Stroke Admission Demographics According to Mechanical Thrombectomy Volume at Admitting Centers

Association between patient demographics and *admission to* substantial volume mechanical thrombectomy centers (with respect to all stroke admissions)

Group	Admissions to high procedural volume centers (% of all stroke admissions)	Univariate analysis. P-value, odds ratio [CI]	Multivariate analysis. P-value, odds ratio [CI]
Ethnicity		(analysis: versus white)	
White	57,711 (8.74%)		
Black	8,788 (8.52%)	**0.019**, 0.972[0.950,0.995]	<**0.001**, 0.616[0.600,0.633]
Hispanic	4,189 (8.78%)	**0.770**, 1.005[0.972,1.038]	<**0.001**, 0.641[0.618,0.665]
Asian/Pacific Islander	1,486 (8.26%)	**0.025**, 0.940[0.891,0.992]	<**0.001**, 0.621[0.585,0.659]
Native American	172 (2.94%)	<**0.001**, 0.317[0.272,0.369]	<**0.001**, 0.328[0.279,0.386]
other	2,465 (11.19%)	<**0.001**, 1.315[1.260,1.373]	**0.0004**, 1.085[1.038,1.135]
Population Density		(analysis: versus central counties with >1million population)	
Central counties with >1 million population	34,418 (12.05%)		
Fringe counties with >1million population	20,557 (8.58%)	<**0.001**, 0.685[0.672,0.697]	<**0.001**, 0.731[0.716,0.747]
Counties with 250K to 1 million	7,989 (4.18%)	<**0.001**, 0.318[0.310,0.326]	<**0.001**, 0.329[0.320,0.338]
Counties with 50K to 250K	4,788 (5.04%)	<**0.001**, 0.388[0.376,0.400]	<**0.001**, 0.250[0.240,0.260]
Micropolitan counties	8,510 (6.06%)	<**0.001**, 0.471[0.459,0.482]	<**0.001**, 0.258[0.249,0.267]
Non-micropolitan/metropolitan counties	6,009 (6.93%)	<**0.001**, 0.544[0.528,0.559]	<**0.001**, 0.352[0.339,0.365]
Median wealth of zipcode		(analysis: versus > $63,000)	
< $39,000	28,194 (9.35%)	**0.0061**, 0.974[0.955,0.992]	<**0.001**, 1.832[1.785,1.881]
$39,000 to 47,999	23,152 (7.67%)	<**0.001**, 0.785[0.769,0.800]	<**0.001**, 1.498[1.461,1.537]
$48,000 to 62,999	19,016 (7.99%)	<**0.001**, 0.820[0.803,0.837]	<**0.001**, 1.219[1.188,1.251]
≥ $63,000	20,146 (9.57%)		
Expected payer		(analysis: versus self-pay)	
Medicare	58,359 (7.62%)	<**0.001**, 0.650[0.627,0.675]	<**0.001**, 0.828[0.791,0.866]
Medicaid	6,926 (12.83%)	<**0.001**, 1.159[1.110,1.211]	**0.0156**, 1.065[1.012,1.120]
Private	21,355 (10.83%)	**0.0268**, 0.957[0.921,0.995]	<**0.001**, 0.893[0.854,0.935]
Self-pay	3,370 (11.26%)		
No charge	435 (13.63%)	<**0.001**, 1.244[1.117,1.385]	**0.3629**, 0.944[0.835,1.068]
Other	1,813 (8.63%)	<**0.001**, 0.755[0.701,0.790]	**0.0358**, 0.929[0.868,0.995]

Table 3

Patient Demographics According to Mechanical Thrombectomy Volume at Treating Centers

Association between patient demographics and *admission to* substantial volume mechanical thrombectomy centers (with respect to all stroke admissions)

Group	Thrombectomy at high procedural volume centers (% of all patients receiving thrombectomy)	Univariate analysis. P-value, odds ratio [CI]	Multivariate analysis. P-value, odds ratio [CI]
Ethnicity		(analysis: versus white)	
White	1299 (76.82%)		
Black	133 (73.51%)	**0.3192**, 0.837[0.591,1.187]	**0.0876**, 0.717[0.489,1.050]
Hispanic	125 (70.92%)	**0.0811**, 0.736[0.522,1.039]	**0.0335**, 0.654[0.442,0.967]
Asian/Pacific Islander	34 (48.98%)	<**0.001**, 0.290[0.179,0.469]	<**0.001**, 0.205[0.120,0.350]
Native American	10 (100%)	**0.9769**, >999[<0.001,>999]	**0.9781**, >999[<0.001,>999]
other	54 (77.71%)	**0.8642**, 1.052[0.590,1.876]	**0.9656**, 0.987[0.535,1.820]
Population Density		((analysis: versus central counties with >1million population)	
Central counties with >1 million population	687 (71.90%)		
Fringe counties with >1million population	506 (75.48%)	**0.109**, 1.203[0.960,1.507]	**0.376**, 1.130[0.862,1.481]
Counties with 250K to 1 million	190 (67.96%)	**0.202**, 0.829[0.621,1.106]	**0.025**, 0.672[0.474,0.951]
Counties with 50K to 250K	184 (76.98%)	**0.115**, 1.307[0.937,1.822]	**0.401**, 1.183[0.799,1.751]
Micropolitan counties	263 (85.99%)	<**0.001**, 2.398[1.686,3.411]	**0.868**, 0.963[0.618,1.501]
Non-micropolitan/metropolitan counties	155 (85.83%)	**0.0001**, 2.367[1.523,3.681]	**0.059**, 1.970[0.975,3.978]
Median wealth of zipcode		(analysis: versus > $63,000)	
< $39,000	675 (81.86%)	**0.0001**, 1.648[1.280,2.121]	**0.0025**, 1.656[1.195,2.297]
$39,000 to 47,999	532 (73.66%)	**0.8649**, 1.021[0.800,1.305]	**0.9759**, 1.005[0.741,1.363]
$48,000 to 62,999	411 (76.71%)	**0.1785**, 1.203[0.919,1.575]	**0.1503**, 1.264[0.919,1.738]
≥ $63,000	443 (73.25%)		
Expected payer		(analysis: versus self-pay)	
Medicare	1078 (73.71%)	**0.1881**, 1.285[0.885,1.866]	**0.0002**, 2.491[1.542,4.023]
Medicaid	184 (84.37%)	**0.0005**, 2.473[1.487,4.114]	**0.0004**, 2.788[1.575,4.934]
Private	700 (81.44%)	**0.0005**, 2.011[1.356,2.981]	<**0.001**, 2.549[1.619,4.013]
Self-pay	97 (68.58%)		
No charge	5 (100%)	**0.9748**, >999[<0.001,>999]	
Other	34 (54.80%)	**0.0601**, 0.555[0.301,1.025]	**0.8883**, 0.950[0.468,1.931]