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Underutilization of Endovascular Therapy in Black Ischemic Stroke Patients: An Analysis of State and Nationwide Cohorts

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Abstract

Background and Purpose: Endovascular therapy (EVT) is a very effective treatment but relies on specialized capabilities that are not available in every hospital where acute ischemic stroke (AIS) is treated. Here, we assess whether access to and utilization of this therapy has extended uniformly across racial and ethnic groups.

Methods: We conducted a retrospective, population-based study using the 2019 Texas Inpatient Public Use Data File. AIS cases and EVT use were identified using the ICD-10 diagnosis and procedure codes. We examined EVT utilization by race/ethnicity and performed patient- and hospital-level analyses. To validate state-specific findings, we conducted patient-level analyses using the 2017 National Inpatient Sample for national estimates. To assess independent associations between race/ethnicity and EVT, multivariable modified Poisson regressions were fitted and adjusted relative risks (aRRs) were estimated accounting for patient risk factors and socioeconomic characteristics.

Results: Among 40,814 AIS cases in Texas in 2019, 54% were White, 17% Black, and 21% Hispanic. Black patients had similar admissions to EVT-performing hospitals and greater admissions to CSCs compared to White patients (EVT 62% vs 62%, p=0.21; CSCs 45% vs 39%, p<0.001) but had lower EVT rates (4.1% vs 5.3%; aRR 0.76 [0.66–0.88], p<0.001). There were no differences in EVT rates between Hispanic and White patients. Lower rates of EVT among Black patients were consistent in the subgroup of patients who arrived in early time windows and received IV-tPA (aRR 0.77 [0.61–0.98], p=0.032) and the subgroup of those admitted to EVT-performing hospitals in both non-CSC (3.0% vs 5.5, p<0.001) and CSC hospitals (7.9% vs 10.4%, p<0.001) while there were no differences between Whites and Hispanic patients.

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Supplemental Materials
Figures S1–S2
Tables S1–S3

Nationwide sample data confirmed this finding of lower utilization of EVT among Black patients (aRR 0.87 [0.77 – 0.98], p=0.024).

Conclusions: We found no evidence of disparity in presentation to EVT-performing hospitals or CSCs; however, lower rates of EVT were observed in Black patients.

Introduction

Endovascular therapy (EVT) is a tremendously impactful treatment for selected patients with large vessel occlusion (LVO) acute ischemic stroke (AIS).[1–3] Effective screening and performance of EVT, however, rely on specialized capabilities that are not available in every hospital that cares for AIS patients.[4] Whether access to and utilization of this therapy has extended uniformly across race and ethnic groups remains incompletely characterized.

In previous studies that examined selected hospital subgroups, Black patients had a lower likelihood of receiving intravenous recombinant tissue plasminogen activator (IV-tPA)[5,6] and EVT compared with White patients.[7] These data, however, excluded a large portion of the population treated at smaller community or rural hospitals or non-comprehensive stroke centers (CSCs). Given the known differences in geographic distribution of population by race, as well as differences in access to different types of health care facilities by race and ethnicity, these prior evaluations of EVT utilization are incomplete.[8]

To evaluate this question in more complete detail, we used a full sample dataset capturing all patients treated during the study period across an entire state, regardless of hospital type. We examine access to and utilization of EVT for AIS by race and also validate our findings in an independent nationwide sample. We hypothesize that Black and Hispanic patients compared to White patients are less likely to receive EVT despite presenting to EVT-performing hospitals.

Methods

Study Design and Study Population

This study was approved by the local institutional review board and the data used for this study are available through the Texas Department of State Health Services (DSHS) and the Healthcare Cost and Utilization Project (HCUP, https://www.hcup-us.ahrq.gov/) under appropriate data use agreements. We followed the REporting of Studies Conducted Using Observational Routinely-collected Data guidelines.[9]

We conducted a retrospective, population-based study using the 2019 Texas Inpatient Public Use Data File (TIPUDF). All hospitals in the State of Texas except those owned by the federal government are required to submit claims on all discharged inpatients using the national uniform billing data element specifications and additional state-required data elements. Submitted claims are consolidated for each discharge covering all services and charges from admission through discharge. The TIPUDF data set includes individual patient-level information such as demographic, clinical, resource utilization, and outcome information and provides hospital information including hospital name and variables indicating whether the hospital is a teaching hospital or other specialty facility. We limited

our population to patients evaluated in 2019 in order to capture a representative modern cohort, after the early and late window EVT trials of 2015 and 2018.

AIS cases were defined as inpatient hospitalizations to acute care hospitals with a primary diagnosis of AIS identified using the International Classification of Diseases, Tenth Revision (ICD-10) diagnosis code I63x (n= 42,547). We excluded AIS cases for patients who were not Texas residents (n=1,348), had missing county information (n=341), and were aged younger than 18 or with missing age information (n=44). For patient-level regression analyses comparing stroke care between Black patients and White patients and between Hispanic patients and White patients, we further excluded patients with unknown sex and other or unknown race/ethnicity (n=6,523). The final cohort (Figure S1) includes 40,814 AIS cases (n=34,291 for regression analyses).

To validate state-specific racial and ethnic differences in stroke care utilization, we conducted patient-level analyses using the 2017 National Inpatient Sample (NIS) for national estimates. The NIS is part of the HCUP, sponsored by the Agency for Healthcare Research and Quality and includes hospital inpatient stays derived from hospital discharge billing data regardless of expected payer. The data is sampled from the State Inpatient Databases from all States participating in HCUP and the 2017 NIS sampling frame includes data from 47 states and the District of Columbia, covering more than 97% of the U.S. population and 96% of discharges from U.S. community hospitals defined as non-federal, short-term, general, and other specialty hospitals. Approximately 20% of discharges were drawn from the sampling frame using a systematic sampling design. There were 104,908 hospitalizations with a primary diagnosis of AIS and among them, 144 AIS cases for the patients who were aged younger than 18 years were excluded (Figure S2). Unweighted 104,764 AIS cases represented 523,820 weighted AIS cases after discharge weights being applied (White 347,275, Black 88,025, Hispanic 41,835, and Other 46,685).

Exposure, Outcome, and Covariates

The combination of race and ethnicity was the primary exposure and categorized into non-Hispanic white (White), non-Hispanic Black (Black), Hispanic and all other race/ethnicity (Other). The primary outcome was EVT utilization by race and ethnicity. Covariates included patient's age, sex, risk factors/comorbidities, insurance status, median household income, urban/rural status, and hospital characteristics including teaching and comprehensive stroke center designation. Median household income was based on US Census zip code level report and was replaced by county level report if the patient's zip code was not available. For the Texas cohort, we cross-walked the American Community Survey (ACS) to determine ZIP code level median household income. If the patient's ZIP code was not available, we use county-level household income from the ACS. For the national cohort, we used the household income quartiles for patient's ZIP Code provided by HCUP NIS. EVT was defined using corresponding ICD-10 procedure codes (Table S1). We determined the transfer status if the source of admission indicated that the admission was through inter-hospital transfer. Although unique patient identifiers were not available to link hospital stays per patient per episode, hospital transfers for acute stroke care occur from EDs and not as inpatient discharges. By selecting patients for the cohort based on discharging hospitals,

we avoided double counting. We verified this assumption using the Florida State Inpatient Data and Emergency Department Datasets by HCUP where unique patient identifiers were available. Urban/rural status was determined based on National Center for Health Statistics urban-rural classification scheme for U.S. counties and county-equivalent entities.

For hospital-level analyses on inequality in AIS care, hospitals were determined as "EVT-performing hospitals" if the hospital submitted at least one claim for EVT in that calendar year.[10] We compared admission rates to EVT-performing hospitals and percentages of patients who received EVT among those admitted to EVT-performing hospitals by race/ethnicity. Among EVT-performing hospitals, we identified CSC status from designation listings published by the Texas DSHS. To be designated as CSC (Level I), hospitals need to be granted certification by The Joint Commission or Det Norske Veritas Global Healthcare.

We then performed several sensitivity analyses. First, we limited the cohort to patients treated with IV-tPA, to better account for differences in time from onset to hospital presentation, as IV-tPA is typically administered within the first 4.5 hours from onset or last known well time. Second, we limited our cohort to patients with AIS and documented NIHSS as secondary diagnoses and examined racial/ethnic differences in EVT rates stratified by NIHSS. To address possible racial differences in the prevalence of LVO, we conducted a sensitivity analysis using the subset of patients with a diagnosis code indicating large vessel occlusion (Table S1).[11,12]

Statistical Analysis

Descriptive statistics were reported and differences by race/ethnicity were assessed using the chi-square tests for categorical variables and Wilcoxon rank-sum (2 groups) or Kruskal-Wallis (>2 groups) tests for continuous variables. To assess independent associations between race/ethnicity and receiving EVT, multivariable modified Poisson regressions were fitted and relative risks (RRs) for receiving EVT were estimated accounting for patient risk factors, socioeconomic characteristics and hospital characteristics as described above.[13] Analyses for the national cohort were performed considering the sampling design and national estimates were produced using the discharge weight.[14] All analyses were conducted using StataMP 16 (StataCorp LLC, College Station, TX).

Results

Patient-level Analysis

Among 40,814 cases with AIS in Texas in 2019, 54% were White, 17% Black and 21% Hispanic. As shown in Table 1, Black and Hispanic patients were younger, more likely to be uninsured and live in lower income neighborhoods compared to White patients. Black patients were more likely to present to hospitals concentrated in large central metropolitan areas. Prevalences for hypertension, heart failure, smoking, and substance abuse were greater in Black patients while atrial fibrillation was more prevalent in White patients, and diabetes more prevalent in Hispanic patients. Black patients had overall longer hospital stays compared to White and Hispanic patients (Table 1).

In univariable analysis, the rate of EVT was lower among Black patients compared to White patients (4.1% vs 5.3%; RR 0.74 [0.65–0.86], p<0.001) while there was no significant difference in EVT rates between White and Hispanic patients (5.3% vs 4.8%; RR 0.93 [0.83–1.04], p=0.23). On the other hand, rates of admission to EVT-performing hospitals were not different between White and Black patients (61.6% vs 62.4%, p=0.21) but were lower among Hispanic patients (61.6% vs 59.1%, p<0.001) (Table 1). In addition, rates of admission to a CSC were greater for Black patients compared to White and Hispanic patients (44.8% vs 38.6% vs 39.6%, p<0.001) and percentages of patients admitted through hospital transfer was the lowest among Black compared to White or Hispanic patients (7.9% vs 9.7% vs 9.1%, p<0.001).

In multivariable analysis, adjusting for age, comorbidities, socio-economic factors and hospital type as shown in Table 2, the probability of undergoing EVT remained lower in Black patients compared to White patients (aRR 0.76 [0.66–0.88], p<0.001). Hispanic patients showed no difference in EVT use compared to White patients.

When we stratified the analysis by the patients' urban/rural status, Black patients residing in urban areas had no difference in the probability of being admitted to EVT-performing hospitals and a higher probability of being admitted to CSC (Figure 1) but still had lower EVT utilization compared to White patients (RR 0.78 [0.68 – 0.89], p <0.001). Among patients residing in rural areas, Black patients were less likely to be admitted to EVT-performing hospitals and had 41% lower EVT utilization compared to White patients (RR 0.59 [0.36 – 0.98], p=0.042). Hispanic patients in urban areas were less likely to be admitted to EVT-performing hospitals but those in rural areas more likely to be admitted to EVT-performing hospitals compared to White patients. Patients in urban areas had higher admission rates to CSCs compared to those in rural areas and Black patients in urban areas had the highest CSC admission rate.

In sensitivity analyses, we first limited the cohort to patients who were treated with IV-tPA (n=5,778), to partially account for differences in time from onset to presentation, as the treatment window for IV-tPA requires presentation within 4.5 hours. In this cohort, we found that the probability of receiving EVT remained lower in Black patients compared to White patients (aRR 0.77 [0.61–0.98], p=0.032), and found no differences between Hispanic and White patients. When we limited our cohort to patients with AIS and documented NIHSS as secondary diagnoses, EVT rates remained lower in Black patients compared to White and Hispanic patients across NIHSS ranges (Table S2). In the analysis using the subset of AIS cases with a diagnosis code indicating LVO, we found that the prevalence of LVO was similar between White and Black patients (29.9% vs 29.0%, p=0.13) and lower among Hispanic patients (27.1%), but still found similar disparities between White and Black patients (16.2% vs 13.7%, p=0.007). When we further restricted the analysis to those with LVO, who were treated at CSC but did not receive IV-tPA, we found that Black patients had still lower rates of EVT (16.7% in Black vs 19.8% in White vs 21.9% in Hispanic, p =0.013). We assumed these patients would have been more likely to present in a delayed fashion at that time EVT was the only potential therapy so racial disparities resulting in decreased offering of EVT would be especially harmful.

Validation in National Inpatient Sample

We evaluated these state-level findings in a larger nationwide sample to assess for generalizability. Among 523,820 weighted AIS cases in the national cohort, 66% were White, 17% were Black, and 8% were Hispanic. Apart from the percentage of Hispanic patients, the demographic characteristics of patients by race/ethnicity were similar to those in the Texas cohort (Table S3). In univariable analysis, rates of EVT were lower in Black patients compared to White patients (3.2% vs. 3.7%, $p<0.05$). Rates of admission to teaching hospitals and larger hospitals were similar across race/ethnicity. In multivariable analysis adjusting for age, sex, comorbidities, insurance, median income, urban/rural status, hospital bed size, teaching hospital status and hospital region, the use of EVT among Hispanic and White patients was not significantly different but the relative use of EVT in Black patients was lower compared to White patients (aRR 0.87 [0.77 – 0.98], p=0.024)

Hospital-Level Analysis

Using the Texas cohort, we conducted hospital-level analyses. There were 298 hospitals where AIS patients were admitted in Texas. Among these hospitals, 62 hospitals were identified as EVT-performing hospitals accounting for 61% of AIS cases. We identified 33 CSC out of 66 EVT-performing hospitals and 81% of EVTs were performed in CSC. Non-CSC EVT-performing hospitals were mostly primary stroke centers. Racial/ethnic compositions of AIS cases were similar across hospital types except disproportionally higher White patients in EVT-performing-non-CSCs (Figure 2. A). Among patients admitted to EVT-performing hospitals, Black patients had lower utilization of EVT compared to White patients both in non-CSC and CSC. Hispanic patients in non-CSC EVT-performing hospitals had lower utilization of EVT compared to White patients (Figure 2.B).

Discussion

In this study using full sample data from a large racially and ethnically diverse state with a mix of urban and rural settings, we observed an approximately 25% lower rates of EVT in Black patients and similar rates in Hispanic patients relative to White patients after adjustment for patient characteristics. These findings were validated using a nationwide sample. There was no evidence that Black patients were more likely to present to hospitals without EVT capability, and this disparity was maintained in CSCs as well as EVT-performing primary stroke centers and in the subset of patients treated with IV-tPA. These findings support further evaluation of racial disparities in access to and utilization of new AIS treatments.

Previous publications have examined disparities in EVT performance by race.[7, 15–17] Rinaldo et al studied AIS patients who were admitted to EVT performing centers and made comparisons between Black/Hispanic patients and non-Hispanic White patients.[15] They found that Black/Hispanic patients were less likely to receive EVT relative to non-Hispanic White patients. Our findings are consistent with those results, but may be more broadly generalizable given the differences in cohorts. The results in this analysis are derived from nearly all hospitals across a state-wide cohort as opposed to EVT-performing centers only. As a result, we were able to perform a more comprehensive assessment of

EVT performance across nearly all hospital types, not just a sample of them. Because a large portion of AIS patients are treated in rural and community hospitals, and inclusion of these locations is particularly relevant given the known differences in racial population distributions by geography. Further, comparisons between combined Black/Hispanic patients with non-Hispanic White patients should be done cautiously. In fact, our study found that Hispanic patients were similar to Black patients in demographic and socioeconomic characteristics but were similar to White patients in the utilization of stroke treatment. In a study using 2006–2014 NIS data, the dataset we used for the national validation cohort, Esenwa et al. assessed recent trends in nationwide EVT utilization and determined if there were racial differences.[16] Because the utilization of EVT has increased rapidly after the publication of the landmark EVT studies in 2015, we believe our national cohort using 2017 NIS data provides more recent estimates.[18–21]

Prior explanations for this disparity, as well as lower IV-tPA utilization rates, have included delayed hospital presentation after symptom onset.[22] Lower rates of emergency medical services utilization by Black patients with AIS has been seen in several cohorts.[5, 22–25] While some of these differences may affect thrombolysis, the eligibility for which is highly dependent on time from symptom onset, it is less likely to affect EVT eligibility, for which the window of treatment has extended to 24 hours from symptom onset and is more dependent on infarct size. To that end, analyses of the Interventional Management of Stroke III Trial data showed no significant differences in cerebral collateral status by race, implying that infarct growth over time should be comparable in Black versus White AIS patients.[26] As such, slight delays in presentation are unlikely to explain the reduced EVT utilization rates. We attempted to address this question of delays in presentation more directly by analyzing the subset of patients treated with IV-tPA, to evaluate the AIS population that presented within 4.5 hours from symptom onset. The RR demonstrating lower EVT utilization in Black patients remained similar in this cohort indicating the contribution of factors other than time-delay as a cause of this disparity.

Another explanation for lower EVT utilization could be reduced rates of treatment eligibility. In this study design, we assume that rates of LVO AIS were consistent across the racial and ethnic categories. This assumption is likely valid given multiple cohorts have shown that rates of large vessel occlusion are likely greater in Black Americans compared to White AIS patients and that rates of cardio-embolism mechanisms of stroke may also be greater.[27,28] In fact, when we identified potential LVO cases using detailed diagnosis codes in the sensitivity analysis, we found a similar prevalence of LVOs between White and Black patients and lower among Hispanic patients. While the atrial fibrillation rates appear to be lower in our cohort in Black patients, this measurement is limited to patients with prior diagnosis or in-hospital diagnosis of the condition.

In our study, there was no evidence of a disparity in access to EVT-performing hospitals or CSCs. As such, access to the procedure seemed commensurate. The lower rates of EVT, however, were observed regardless of hospital certification type. Black patients residing in rural areas were less likely to be admitted to EVT-performing hospitals and had lower rates of EVT regardless of their residence.

Other factors that may contribute to differences in EVT rates according to race include structural and institutional racism and provider bias. The impact of structural racism and implicit bias have not been extensively studied in relationship to acute stroke care; however, a number of studies demonstrate their potential role in mediating racial disparities in stroke care. Stroke center certification is associated with decreased disparities in acute stroke treatment.[22] The use of protocols to enhance care quality may address biases that lead to differences in patient management. Acute care metrics including door to needle time (DTNT) have been shown to differ according to race, with many studies showing longer DTNT in Black compared to White patients.[29,30] Other studies have shown delayed wait times after hospital arrival for Black and Hispanic patients compared to White patients.[31,32] Further study of the role of structural racism and implicit bias on under-utilization of EVT for ischemic stroke patients is needed.

Our study has several limitations. First, we acknowledge that race and ethnicity can be misclassified in administrative datasets.[33] In addition, as mentioned above, administrative data analyses are unable to directly measure a number of features important in evaluating EVT eligibility, including presence and location of LVO, infarct core, and others. On the other hand, existing descriptions of LVO frequency make it unlikely that fewer Black patients were eligible for EVT. Further, stroke severity, time last known well, mode of transportation, and stroke center status were not available to be included in the multivariable analysis. Also, compared to prior publications, our rates of EVT utilization may be slightly less compared to data from single centers or registries. This difference, however, is likely related to our cohort, which includes a large proportion of smaller and lower volume hospitals. Another consideration is the generalizability of these results, given the primary outcome was derived from a single state cohort, which may not be representative of the rest of the country. It is also possible that one of the hypothesized sources of EVT performance disparity is the offering of the procedure to patients associated with institutional racism, which may vary by geographies. While we attempted to address this question by studying a nationwide cohort as well, and by comparing our results against prior publications using different cohorts, it is not possible to quantify whether the disparity we observe would be similar in different locations. As a result, we believe that further study, focusing on smaller scales such as statewide or even more immediate cohorts, is important to better understand the source of these disparities.

In this study of full sample data from a single state and subsequent validation in a nationwide cohort, we observed lower rates of EVT in Black AIS patients. These differences were persistent in larger, urban hospitals as well as smaller rural hospitals, as well as in CSC and non-CSC hospitals performing EVT, and in the subset of patients treated with IV-tPA. These findings support further evaluation of the factors contributing to racial disparities in access to and utilization of new AIS treatments.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Disclosure

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Nonstandard Abbreviations and Acronyms

EVT	endovascular therapy
LVO	large vessel occlusion
AIS	ischemic stroke
IV-tPA	intravenous recombinant tissue plasminogen activator
CSC	comprehensive stroke center

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		% of AIS (95% CI)	Relative Risk (95% CI)
Admission to EVT-performing hospital			
Urban	White	63.0 (62.2 - 63.7)	1.00
	Black	63.8 (62.6 - 65.0)	1.01 (0.99 - 1.04)
	Hispanic	58.8 (57.7 - 59.9)	0.93 (0.91 - 0.96)
Rural	White	55.3 (53.7 - 56.8)	1.00
	Black	47.2 (43.0 - 51.4)	0.85 (0.78 - 0.93)
	Hispanic	61.6 (58.4 - 64.8)	1.11 (1.05 - 1.18)
Admission to CSC			
Urban	White	40.6 (39.9 - 41.4)	1.00
	Black	46.2 (45.0 - 47.5)	1.14 (1.10 - 1.17)
	Hispanic	40.8 (39.7 - 41.9)	1.00 (0.97 - 1.04)
Rural	White	29.4 (28.0 - 30.9)	1.00
	Black	29.5 (25.8 - 33.5)	1.00 (0.88 - 1.15)
	Hispanic	30.1 (27.1 - 33.1)	1.02 (0.92 - 1.14)
EVT received			
Urban	White	5.4 (5.1 - 5.7)	1.00
	Black	4.2 (3.7 - 4.7)	0.78 (0.68 - 0.89)
	Hispanic	5.0 (4.5 - 5.5)	0.92 (0.82 - 1.04)
Rural	White	4.8 (4.2 - 5.5)	1.00
	Black	2.8 (1.6 - 4.6)	0.59 (0.36 - 0.98)
	Hispanic	3.4 (2.3 - 4.7)	0.70 (0.48 - 1.01)

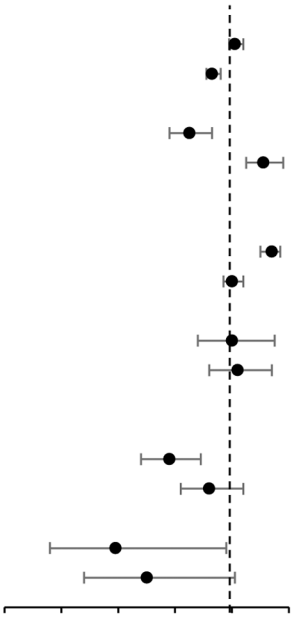
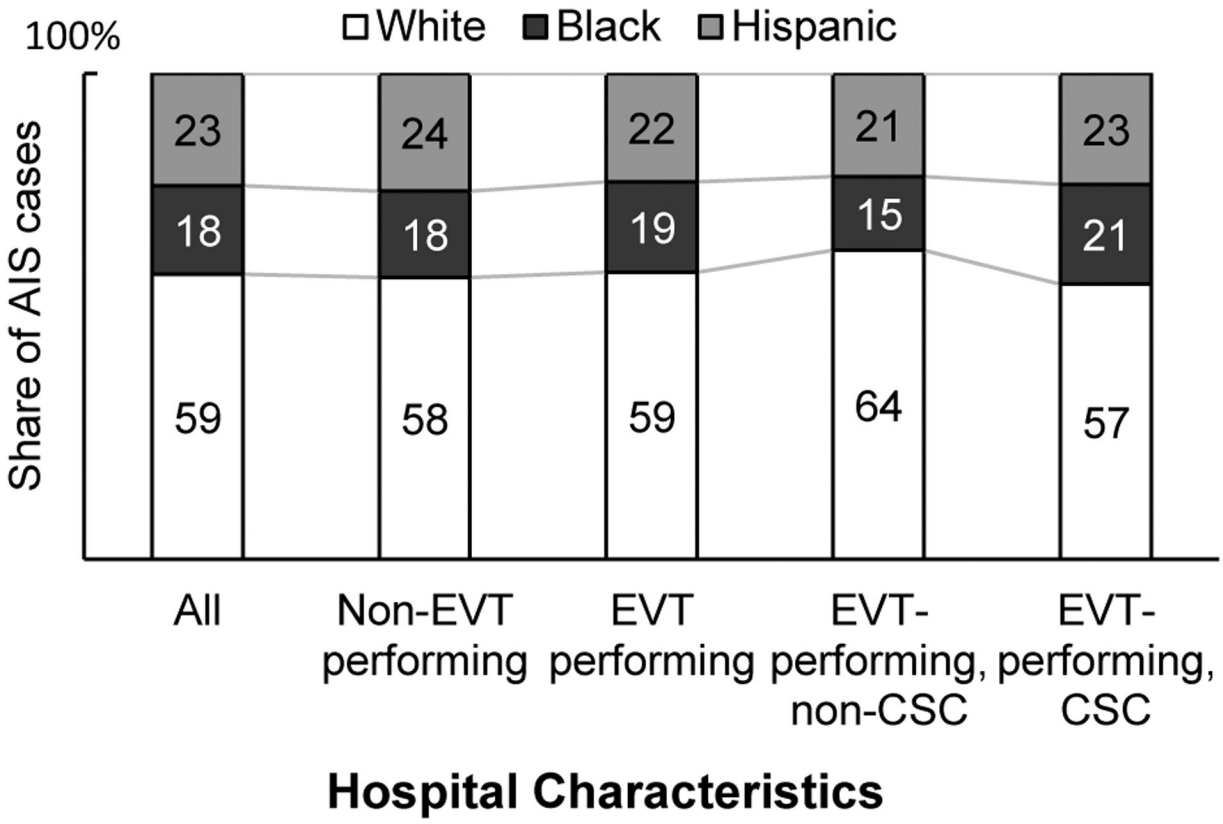


Figure 1. Rates of admission to EVT-performing hospitals and CSC and utilization of EVT by race/ethnicity according to patient's residence.

Percentages of AIS patients who were admitted to EVT-performing hospital and CSC were estimated and compared by race/ethnicity. Percentages of AIS patients who received EVT were estimated and compared by race/ethnicity as well.



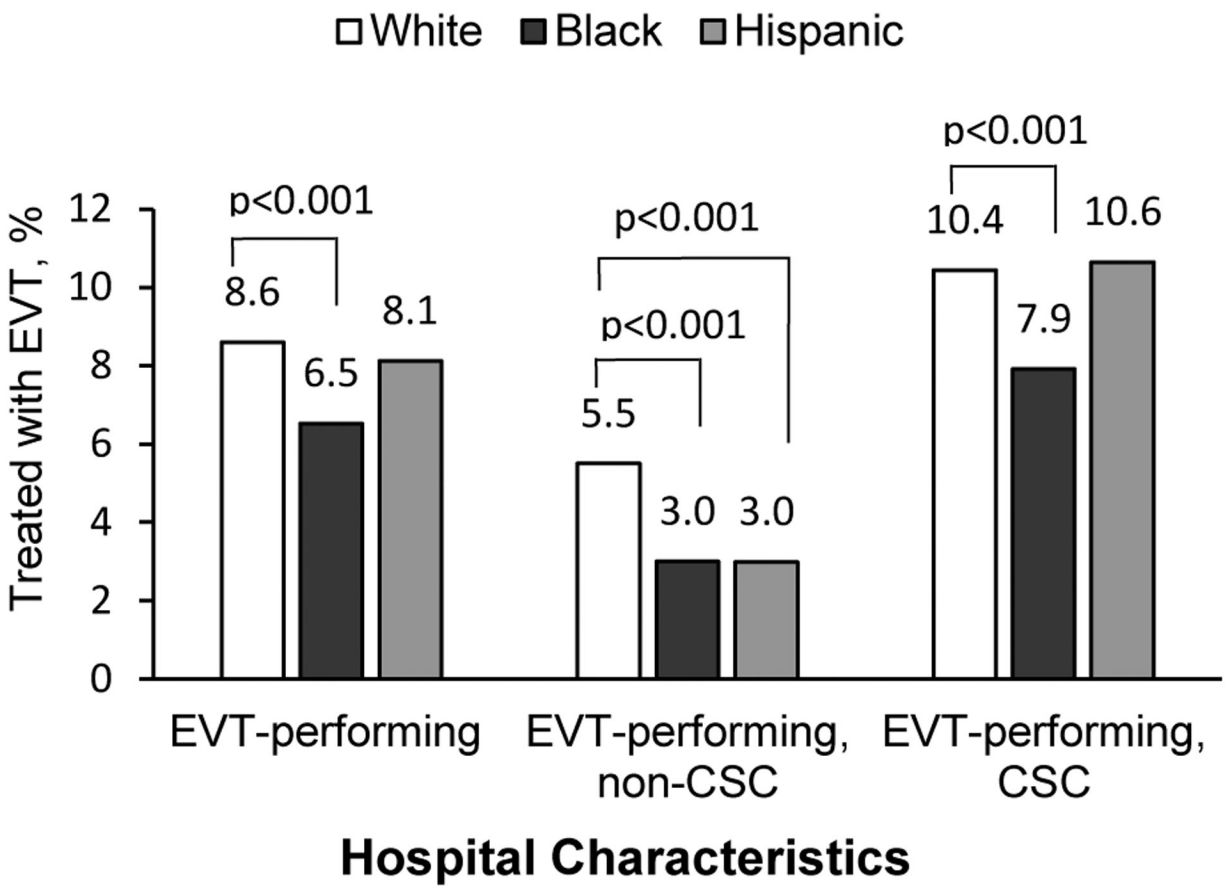


Figure 2. Distribution of AIS by race/ethnicity according to hospital characteristics and EVT utilizations by race/ethnicity in EVT- performing hospitals.

Panel A shows proportions of AIS cases by race/ethnicity in hospitals characterized with EVT capability and CSC status. Panel B shows EVT utilization among those admitted to EVT performing hospitals in regard to CSC status. Significant differences between Whites and Blacks and between Whites and Hispanics were tested and p-values <.05 are reported.

Table 1.

Characteristics of AIS Patients and Hospital Stays by Race/Ethnicity, Texas Hospital Discharge 2019

	All	White	Black	Hispanic	Other	p-value		
AIS, n	**40,814**	**21,864**	**6,819**	**8,576**	**3,555**	**W,B,H**	**W:B**	**W:H**
Age, %						<0.001	<0.001	<0.001
18–44	5.3	3.7	7.9	7.2	5.9			
45–64	33.6	27.3	45.8	38.8	36.1			
65–74	25.5	26.0	25.2	25.0	24.6			
75–84	22.0	25.9	13.7	18.9	21.3			
85+	13.6	17.2	7.3	10.1	12.1			
Age<65, %	38.9	31.0	53.8	46.0	42.0	<0.001	<0.001	<0.001
Female, %	51.1	51.1	54.8	49.2	48.6	<0.001	<0.001	0.003
Primary payment, %						<0.001	<0.001	<0.001
Private	19.8	20.3	20.8	17.9	19.7			
Medicare	58.4	65.0	49.9	50.3	54.0			
Medicaid	4.3	2.5	7.7	6.3	4.7			
Uninsured	13.5	8.9	16.5	21.2	16.9			
Other	3.9	3.3	5.0	4.2	4.6			
Median household incomes, %						<0.001	<0.001	<0.001
$1 – $43,999	27.1	17.9	34.9	45.7	24.4			
$44,000 – $55,999	26.8	27.6	24.6	26.8	25.9			
$56,000 – 73,999	25.3	28.3	26.0	18.0	23.5			
$74,000 or more	20.7	26.2	14.5	9.4	26.2			
Urban Rural Classification, %						<0.001	<0.001	<0.001
Large Central Metro	44.1	37.1	62.7	43.4	53.2			
Large Fringe Metro	17.4	21.7	12.5	9.8	18.4			
Medium Metro	16.2	13.4	9.1	31.6	10.0			
Small Metro	8.1	9.7	7.5	4.4	8.1			
Micropolitan	7.0	8.4	4.7	6.4	4.9			
Non-core	7.2	9.8	3.5	4.3	5.5			
Comorbidities, %								
Diabetes	45.8	38.3	50.3	60.5	47.7	<0.001	<0.001	<0.001
Hypertension	87.6	86.3	91.0	88.7	86.8	<0.001	<0.001	<0.001
Heart Failure	17.9	17.4	23.2	16.0	15.6	<0.001	<0.001	0.003
Myocardial Infarction	9.3	10.1	9.4	7.9	7.8	<0.001	0.12	<0.001
Dyslipidemia	64.0	63.6	63.2	65.4	64.9	0.005	0.59	0.003
Atrial Fibrillation	21.6	26.2	14.0	16.4	20.1	<0.001	<0.001	<0.001
Obesity	16.4	14.7	19.2	19.7	13.6	<0.001	<0.001	<0.001
Smoking	20.3	20.2	27.0	15.8	19.7	<0.001	<0.001	<0.001
Alcohol abuse	4.4	4.4	4.4	4.6	4.0	0.85	0.93	0.60
Substance abuse	3.9	3.0	7.4	3.7	2.9	<0.001	<0.001	0.004
NIHSS documented, %	59.2	58.4	61.0	58.8	62.2	<0.001	<0.001	0.51

	All	White	Black	Hispanic	Other	p-value		
AIS, n	**40,814**	**21,864**	**6,819**	**8,576**	**3,555**	**W,B,H**	**W:B**	**W:H**
Length of Stay								
Median [IQR], days	3[2–6]	3 [2–6]	4 [2–7]	4 [2–6]	4 [2–6]	<0.001	<0.001	<0.001
Prolonged stay (> 7 days), %	17.0	15.0	21.1	18.0	19.1	<0.001	<0.001	<0.001
Discharge disposition, %								
Discharge home	52.8	50.2	53.8	58.8	52.6	<0.001	<0.001	<0.001
Inpatient Rehab	20.7	21.4	21.2	18.4	21.2	<0.001	0.77	<0.001
Transfer to another acute hospital	1.9	2.0	1.8	1.8	2.0	0.44	0.36	0.28
SNF/LTCF	15.0	15.8	15.4	12.9	13.7	<0.001	0.46	<0.001
Expired/Hospice	7.7	8.7	5.1	6.6	9.0	<0.001	<0.001	<0.001
Other	1.9	2.0	2.6	1.5	1.5	<0.001	0.001	0.003
Transferred-In. %	9.5	9.7	7.9	9.1	12.5	<0.001	<0.001	0.12
IV-tPA or EST, %	17.5	18.0	15.5	16.9	19.9	<0.001	<0.001	0.015
IV-tPA, %	14.2	14.6	12.8	13.8	14.8	<0.001	<0.001	0.08
IV-tPA prior to admission, %	3.0	3.1	2.3	2.7	3.7	<0.001	<0.001	0.06
EVT, %	5.2	5.3	4.1	4.8	8.0	<0.001	<0.001	0.08
Hospital characteristics, %								
EVT performing hospital	61.6	61.6	62.4	59.1	66.2	<0.001	0.21	<0.001
Teaching hospital	32.1	29.6	41.6	31.8	30.1	<0.001	<0.001	<0.001
Comprehensive Stroke Center	39.9	38.6	44.8	39.6	38.6	<0.001	<0.001	0.09

AIS, acute ischemic stroke; W, Whites; B, Black; H, Hispanic; NIHSS, NIH stroke scale; SNF, skilled nursing facility; LTCF, long-term care facility; IV-tPA, intravenous recombinant tissue plasminogen activator; EVT, endovascular therapy. P-values were reported from the chi-square tests for categorical variables and Wilcoxon rank-sum (2 groups) or Kruskal-Wallis (>2 groups) tests for continuous variables.

Table 2.

Probability of Receiving EVT, Texas Hospital Discharge 2019

	Crude RR (95% CI)	p-value	Adjusted RR (95% CI)	p-value
Race/ethnicity				
White	1 (reference)		1 (reference)	
Black	0.74 (0.65–0.86)	<0.001	0.76 (0.66–0.88)	<0.001
Hispanic	0.93 (0.83–1.04)	0.23	1.03 (0.91–1.16)	0.67
Age				
18–64	1 (reference)		1 (reference)	
65–74	1.02 (0.90–1.15)	0.81	0.96 (0.83–1.11)	0.61
≥75	1.19 (1.07–1.33)	0.002	0.91 (0.78–1.05)	0.21
Female	1.03 (0.93–1.13)	0.58	1.05 (0.95–1.15)	0.34
Comorbidities				
Diabetes	0.65 (0.59–0.72)	<0.001	0.73 (0.66–0.81)	<0.001
Hypertension	0.70 (0.62–0.79)	<0.001	0.70 (0.62–0.79)	<0.001
Heart Failure	1.64 (1.47–1.82)	<0.001	1.29 (1.15–1.44)	<0.001
Myocardial Infarction	1.19 (1.03–1.38)	0.02	1.11 (0.96–1.29)	0.17
Dyslipidemia	0.79 (0.72–0.87)	<0.001	0.85 (0.77–0.93)	0.001
Atrial Fibrillation	2.82 (2.57–3.09)	<0.001	2.52 (2.28–2.79)	<0.001
Obesity	1.11 (0.99–1.26)	0.08	1.22 (1.08–1.38)	0.002
Smoking	0.85 (0.75–0.97)	0.014	0.97 (0.85–1.10)	0.60
Primary payment				
Private	1 (reference)		1 (reference)	
Medicare	1.10 (0.97–1.25)	0.13	0.96 (0.83–1.10)	0.55
Medicaid	0.97 (0.74–1.28)	0.83	0.94 (0.72–1.24)	0.67
Uninsured	1.09 (0.92–1.30)	0.32	1.04 (0.87–1.24)	0.68
Other	1.29 (1.01–1.65)	0.045	1.11 (0.87–1.41)	0.40
Median household income				
$1 – $43,999	1 (reference)		1 (reference)	
$44,000 – $55,999	0.90 (0.79–1.02)	0.09	0.91 (0.80–1.04)	0.16
$56,000 – 73,999	0.93 (0.81–1.05)	0.24	0.87 (0.76–0.99)	0.042
$74,000 or more	1.02 (0.89–1.16)	0.79	0.93 (0.80–1.06)	0.28
Urban Rural Classification				
Rural	1 (reference)		1 (reference)	
Urban	1.11 (0.97–1.27)	0.13	0.95 (0.82–1.09)	0.46
Teaching hospital	2.01 (1.83–2.20)	<0.001	1.02 (0.93–1.13)	0.64
Comprehensive Stroke Center	6.39 (5.67–7.20)	<0.001	6.04 (5.31–6.86)	<0.001

EVT, endovascular therapy; RR, relative risk of receiving EVT. To assess independent associations between race/ethnicity and receiving EVT, multivariable log-binomial regressions were fitted and relative risks were estimated accounting patient risk factors, socioeconomic characteristics and hospital characteristics.