

Disparities in the Use of Intravenous t-PA among Ischemic Stroke Patients: Population-based Recent Temporal Trends

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Objective: To explore a 5-year comparison of disparities in intravenous t-PA (IV t-PA) use among acute ischemic stroke (AIS) patients based on race, gender, age, ethnic origin, hospital status, and geographic location. *Methods:* We extracted patients' demographic information and hospital characteristics for 2010 and 2014 from the New York Statewide Planning and Research Cooperative System (SPARCS). We compared disparities in IV t-PA use among AIS patients in 2010 to that in 2014 to estimate temporal trends. Multiple logistic regression was performed to compare disparities based on demographic variables, hospital designation, and geographic location. *Results:* Overall, there was approximately a 2% increase in IV t-PA from 2010 to 2014. Blacks were 15% less likely to receive IV t-PA compared to Whites in 2014, but in 2010, there was no difference. Patients aged 62-73 had lower odds of receiving IV t-PA than age group ≤ 61 in both 2010 and 2014. Designated stroke centers in the Lower New York State region were associated with reduced odds of IV t-PA use in 2010 while those located in the Upper New York State region were associated with increased odds of IV t-PA use in both 2010 and 2014, compared to their respective nondesignated counterparts. Gender, ethnic origin, and insurance status were not associated with IV t-PA utilization in both 2010 and 2014. *Conclusion:* Overall IV t-PA utilization among AIS patients increased between 2010 and 2014. However, there are evident disparities in IV t-PA use based on patient's race, age, hospital geography, and stroke designation status.

Key Words: Tissue plasminogen activator—stroke treatment disparities—racial disparities—acute ischemic stroke—stroke treatment—trombolysis—administrative database

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Introduction

Ischemic stroke is the leading cause of long-term disability and fifth leading cause of death worldwide.¹ There

is evidence that racial, gender, age, ethnic, and geographic location disparities are found with utilization and prescription of medication.² A greater understanding of these disparities, particularly in the administration of time

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sensitive medications is warranted to ensure better quality patient care. Researchers have attempted to examine whether various demographic variables (eg, race, age, gender, ethnicity, geographic location) predict patient treatment, yet research on disparities of IV t-PA have been investigated with equivocal results.³⁻⁹

Increased age has been a consistent predictor of likelihood of experiencing an ischemic stroke.¹⁰ There is clear evidence that there are negative attitudes toward older adults compared to younger adults, and this is even shown when comparing older adults to the oldest old (85+).¹¹ Even with this known bias, no research to date has addressed age disparities, specifically in regards to IV t-PA rates.

Our present study investigates IV t-PA administration disparities over time across demographic factors (ie, geographic, sex, race, ethnicity, age) using a population-based sample of New York State residents with acute ischemic stroke (AIS).

Methods

Procedures

The Institutional Review Board at the State University of New York, Downstate Medical Center approved this study. This study utilized secondary data that include inpatient discharges accessed from the New York State-wide Planning and Research Cooperative System (SPARCS) for the years 2010 and 2014.¹² Data collected by SPARCS consist of comprehensive inpatient and outpatient data including patient level information on demographics, clinical information such as diseases and procedures, various auxiliary services, charges for services, and some hospital level information such as location, hospital type, and other administrative information associated with each of the patient records.¹² Any health care facility licensed to provide services is required to report patient level data to SPARCS within 60 days of discharge.¹² SPARCS covers about 98% of the hospitalization records in New York State, which makes it one of the most comprehensive hospital discharge databases.¹²

From this dataset, we extracted patient-specific data for hospitalizations with a primary diagnosis of stroke during 2010 and 2014. The dependent variable was a binary variable indicating whether IV t-PA was administered during these hospitalizations. Patient level characteristics such as race, sex, age, ethnicity, and primary insurance type were used as independent variables. Age quartiles (≤ 61 , 62-72, 73-82, and 83 years and over) were determined based on the age distribution in the extracted stroke patient dataset.

SPARCS data used different race categories for 2010 and 2014. To maintain consistency in the race categories for comparison, we used the SPARCS data dictionaries for 2010 and 2014 and categorized patient's race as White, Black, Asian, and other. Ethnicity was coded as Spanish/Hispanic origin and not of Spanish/Hispanic origin.¹² Primary insurance was categorized as Medicaid, Medicare,

Private, Self-Pay, No Payment, and Other. Geographical region was divided into 2 regions: lower New York State (Queens, Kings, Bronx, Richmond, Manhattan, Westchester, Nassau and Suffolk counties) and upper New York State (all other counties in New York State). Hospitals were subcategorized as either a designated stroke center or nondesignated stroke center, as determined by the New York State Department of Health's designated stroke center database for those years based on standards that are available on the New York State Department of Health (DOH) website.¹³ The New York State DOH appointed a steering committee in the spring of 2002 consisting of neurologists, Emergency Department physicians, and representatives from the New York State DOH, New York City Fire Department Emergency Medical Service (FDNY EMS) and Island Peer Review Organization, Inc. (IPRO) who developed criteria for stroke center designation and quality indicators. The Brain Attack Coalition published guidelines for the establishment of primary stroke centers were used.^{14,15}

We also used 2014 population data to visualize racial distribution and population density by counties of New York State on geographic maps. These data were collected from the New York State Department of Health's website.¹⁶

Sample

The dataset used for this study consisted of 32,546 and 33,190 stroke-related discharge records from 2010 and 2014, respectively. The distribution of IV t-PA use by patient's demographic characteristics, and hospital's designation and geographic location for the 2 cohorts are summarized in [Figure 1](#).

Data Analysis

Descriptive analyses were performed to generate basic statistics on IV t-PA use by race, ethnicity, sex, age, primary insurance type, and designated stroke centers in Lower New York state and Upper New York state and are presented in [Figure 1](#).

We used multiple logistic regression models to determine if there were demographic disparities in IV t-PA administration, separately for 2010 and 2014. The outcome for the multiple logistic regression models was IV t-PA use, and the predictors were primary insurance type, race, ethnicity, sex, age quartile, admission to a designated stroke center, and region (lower New York State versus upper New York State). The first order interaction terms between designated stroke center and region, sex and region and between sex and race were investigated. Odds ratios of IV t-PA, along with their 95% confidence intervals (CI) and *P* values were reported ([Table 1](#)). *P* < .05 was considered statistically significant. All predictors were deemed important on clinical grounds and remained in the models, regardless of their statistical significance. The unit of data analysis in this study was per

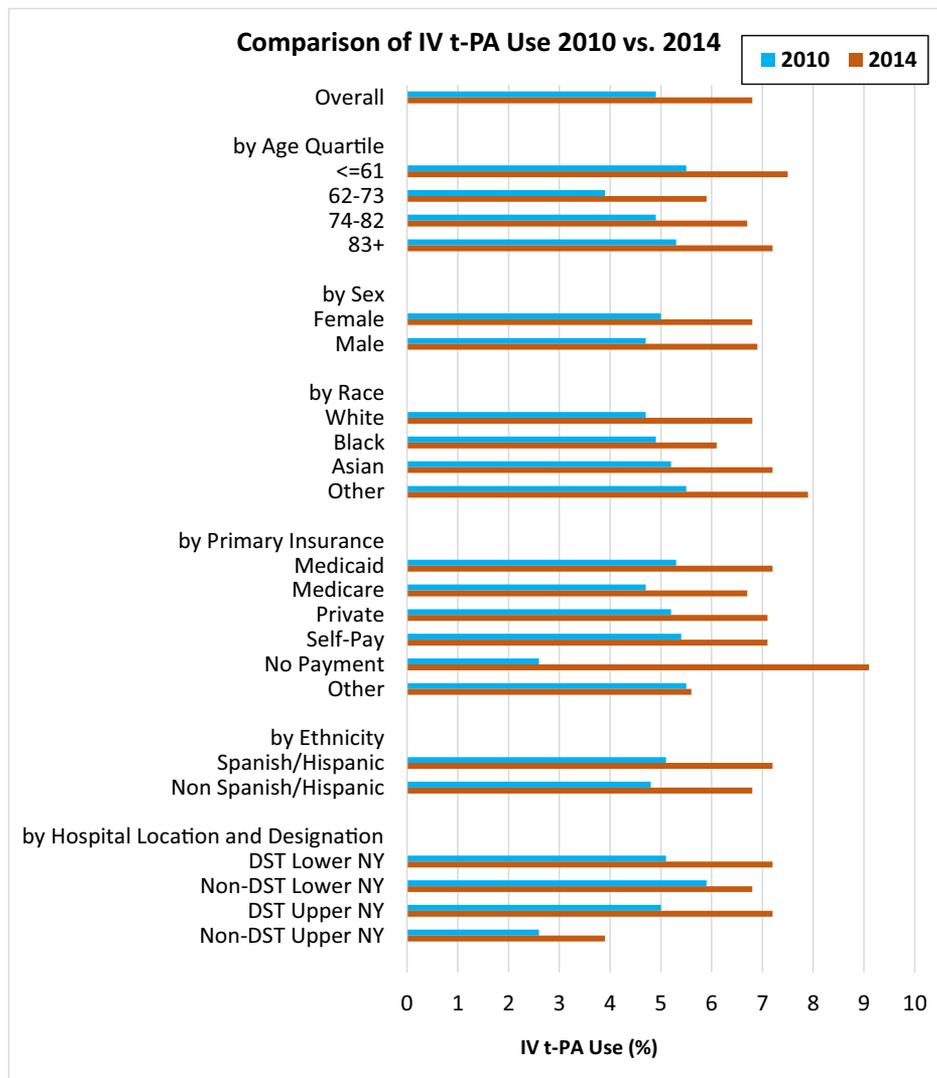


Figure 1. Comparison of IV t-PA use by various patient characteristics, hospital designation and location: 2010 versus 2014. Abbreviations: DST, designated stroke center; NON-DST, nondesignated stroke center.

record and not per patient. All the statistical analyses were performed using SAS 9.4 (SAS Institute, Inc., Cary, North Carolina) software. To display county-level differences in stroke incidence, population density, hospital designation status by geographic location, and racial distribution of New York State population, maps were created using ArcMap 10.3.1 (Environmental Systems Research Institute, Redlands, California) software.

Results

There was a 1.9% increase (4.9% in 2010 versus 6.8% in 2014; $P < .0001$) in IV t-PA utilization among AIS patients who were hospitalized within New York State (Fig 1). The increase in IV t-PA use in 2014 compared to IV t-PA use in 2010 was consistent when we compared patients' age quartile, sex, race, ethnic origin, primary payer type, and hospital region (Fig 1).

Among the study population, female stroke patients decreased by 1.4%, from 52.1% in 2010 to 50.7% in 2014 ($P = .0003$). In both years, over 75% of the stroke patients were at least 62 years old. Figure 2 illustrates county-level differences in stroke incidence and geographic distribution of hospitals by stroke designation in each county between 2010 and 2014. There were 88 designated and 109 nondesignated stroke centers in 2010 in New York State. In 2014, the number of designated stroke centers increased to 94 (mostly in lower New York State) while the total number of nondesignated stroke centers decreased to 104 (mostly in upper New York State) compare to 2010. Counties in lower New York State had higher stroke incidences and higher concentration of both designated and nondesignated stroke centers in both 2010 and 2014 compared to counties in upper New York State. To better understand these differences, Figure 3 illustrates a geographic distribution of both designated and

Table 1. The adjusted odds ratios for IV t-PA use based on selected patient characteristics, 2010 versus 2014

| Variable | Category | 2010 | | | 2014 | | |
|-----------------------------------|---|------------|-------------|---------|------------|-------------|---------|
| | | Odds ratio | 95% CI | P value | Odds ratio | 95% CI | P value |
| Insurance (primary payer) | | | | | | | |
| | Medicaid vs self-pay | .93 | (.61-1.41) | .718 | 1.01 | (.71-1.45) | .954 |
| | Medicare vs self-pay | .86 | (.57-1.3) | .467 | 1.02 | (.71-1.45) | .923 |
| | Private vs self-pay | .95 | (.63-1.43) | .811 | 1.01 | (.71-1.45) | .939 |
| | No payment vs self-pay | .49 | (.11-2.09) | .333 | 1.25 | (.42-3.69) | .687 |
| | Other vs self-pay | 1.06 | (.63-1.78) | .838 | .8 | (.5-1.29) | .359 |
| Race | | | | | | | |
| | Asian vs White | .93 | (.68-1.29) | .677 | 1.02 | (.8-1.31) | .862 |
| | Black vs White | .91 | (.78-1.05) | .183 | .85 | (.75-.96) | .009 |
| | Other vs White | 1.1 | (.89-1.34) | .383 | 1.16 | (1.01-1.34) | .040 |
| Ethnic origin | | | | | | | |
| | Spanish/Hispanic vs non-Spanish/Hispanic | .88 | (.71-1.08) | .219 | .93 | (.78-1.1) | .402 |
| Sex | | | | | | | |
| | Female vs Male | 1.04 | (.94-1.16) | .445 | .99 | (.91-1.08) | .858 |
| Age (quartile) | | | | | | | |
| | 62-73 vs age \leq 61 | .74 | (.62-.87) | .0003 | .78 | (.68-.89) | <.0001 |
| | 74-82 vs age \leq 61 | .98 | (.81-1.17) | .807 | .88 | (.76-1.03) | .101 |
| | 83+ vs age \leq 61 | 1.03 | (.86-1.25) | .732 | .95 | (.82-1.11) | .540 |
| Hospital geographic region | | | | | | | |
| | Lower New York State: Designated stroke center vs nondesignated stroke center | .81 | (.71-.93) | .003 | 1.04 | (.92-1.17) | .530 |
| | Upper New York State: Designated stroke center vs nondesignated stroke center | 1.94 | (1.60-2.36) | <.0001 | 1.93 | (1.58-2.35) | <.0001 |

nondesignated stroke centers in both upper and lower New York State counties and population densities of the areas (per square mile) where these centers are located.

We found that IV t-PA use differed among age quartiles ($P < .001$) in both 2010 and 2014. The age group from 62 to 73-year-old AIS patients had a significantly lower rate of IV t-PA use compared to AIS patients under the age of 62 in both 2010 (OR = .74, 95% CI .62-.87, $P < .001$) and 2014 (OR = .78, 95% CI .68-.89, $P < .001$). However, there was no significant difference found when comparing the age group from 74 to 82-year-old AIS patients and AIS patients that were 83 or older with AIS patients under 62 in both 2010 and 2014 (Table 1). We did not find a significant difference in IV t-PA use between males and females in 2010 (OR = 1.04, 95% CI .94-1.16, $P = .445$) and 2014 (OR = .99, 95% CI .91-1.08, $P = .86$). There was less than a .3% difference between males and females IV t-PA use (Fig 1), in both 2010 and 2014. Further, in 2014 rates of IV t-PA use increased by 2.2% from 2010 for males and by 1.8% for female stroke patients. The first order interaction terms between sex and region ($P = .71$ and $P = .21$ for 2010 and 2014 resp.) and sex and race ($P = .32$ and $P = .79$ for 2010 and 2014 respectively) were investigated but were

not included in the final regression models as they were not significant.

Fig 4 illustrates racial distribution of New York state population on maps. It is evident that lower New York State has a higher concentration of all races compare to upper New York State. Race was significantly associated with IV t-PA use in 2014 ($P = .002$), but not in 2010 ($P = .36$). In 2014, the rate of IV t-PA use was higher among patients who selected Other as their race compared to Whites (OR = 1.16, 95% CI 1.01-1.34, $P = .04$). The IV t-PA use was lower in Blacks than in Whites (OR = .85, 95% CI .75-.96, $P = .009$) in 2014. There was no significant difference in IV t-PA use between ethnicity groups in both 2010 (OR = .88, 95% CI .71-1.08, $P = .219$) and 2014 (OR = .93, 95% CI .78-1.1, $P = .402$). From 2010 to 2014, rates of IV t-PA use increased for patients of both Spanish or Hispanic origin (2.2% increase) and Non-Spanish/Hispanic origin (2% increase) (Fig 1).

We investigated whether admissions to designated stroke centers were associated with higher odds of IV t-PA use compared to nondesignated stroke centers. The results differed between lower and upper New York State regions. The difference was demonstrated by the significant first

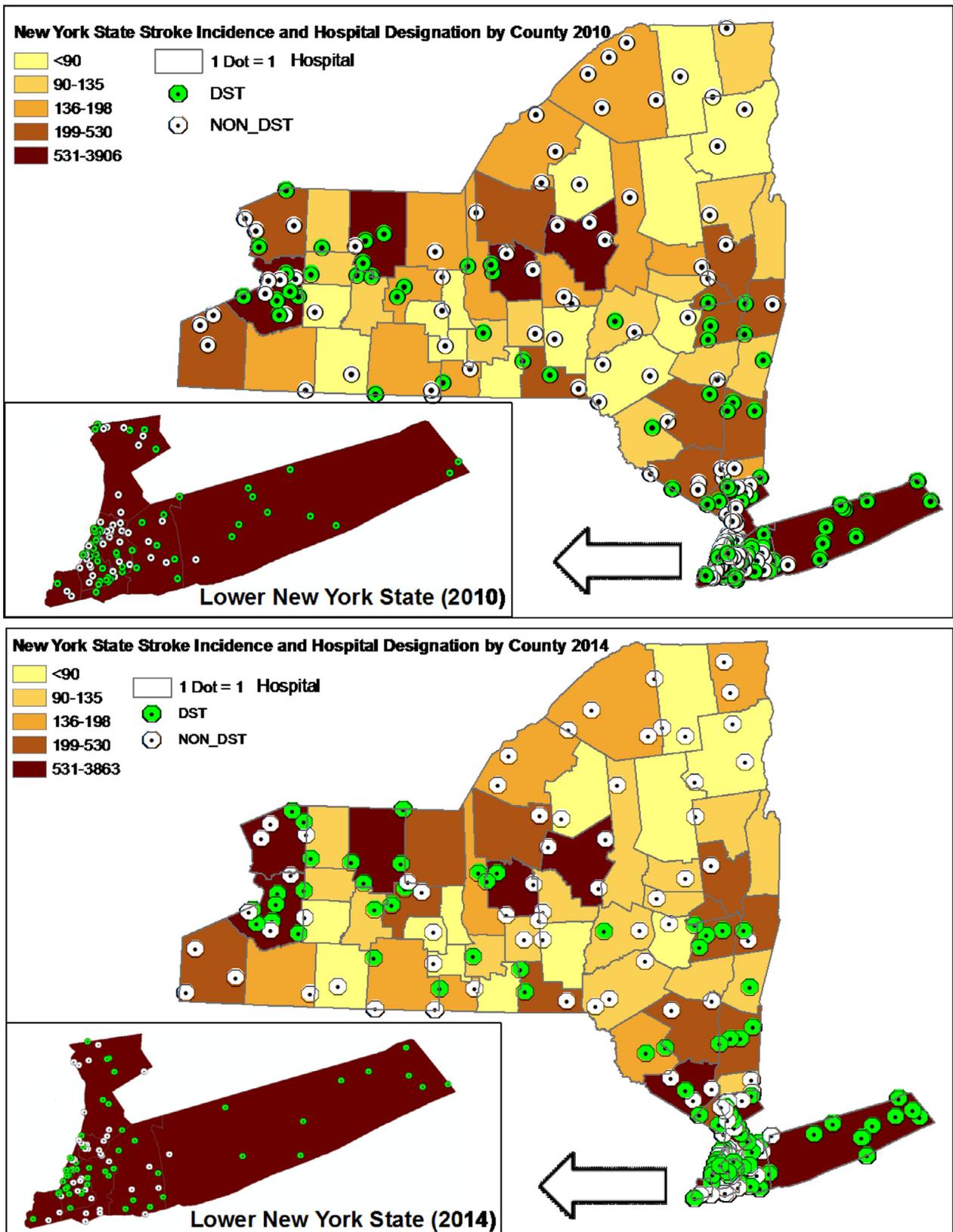


Figure 2. Stroke incidence and hospital designation by County 2010 and 2014. Abbreviations: DST, designated stroke center; NON-DST, nondesignated stroke center.

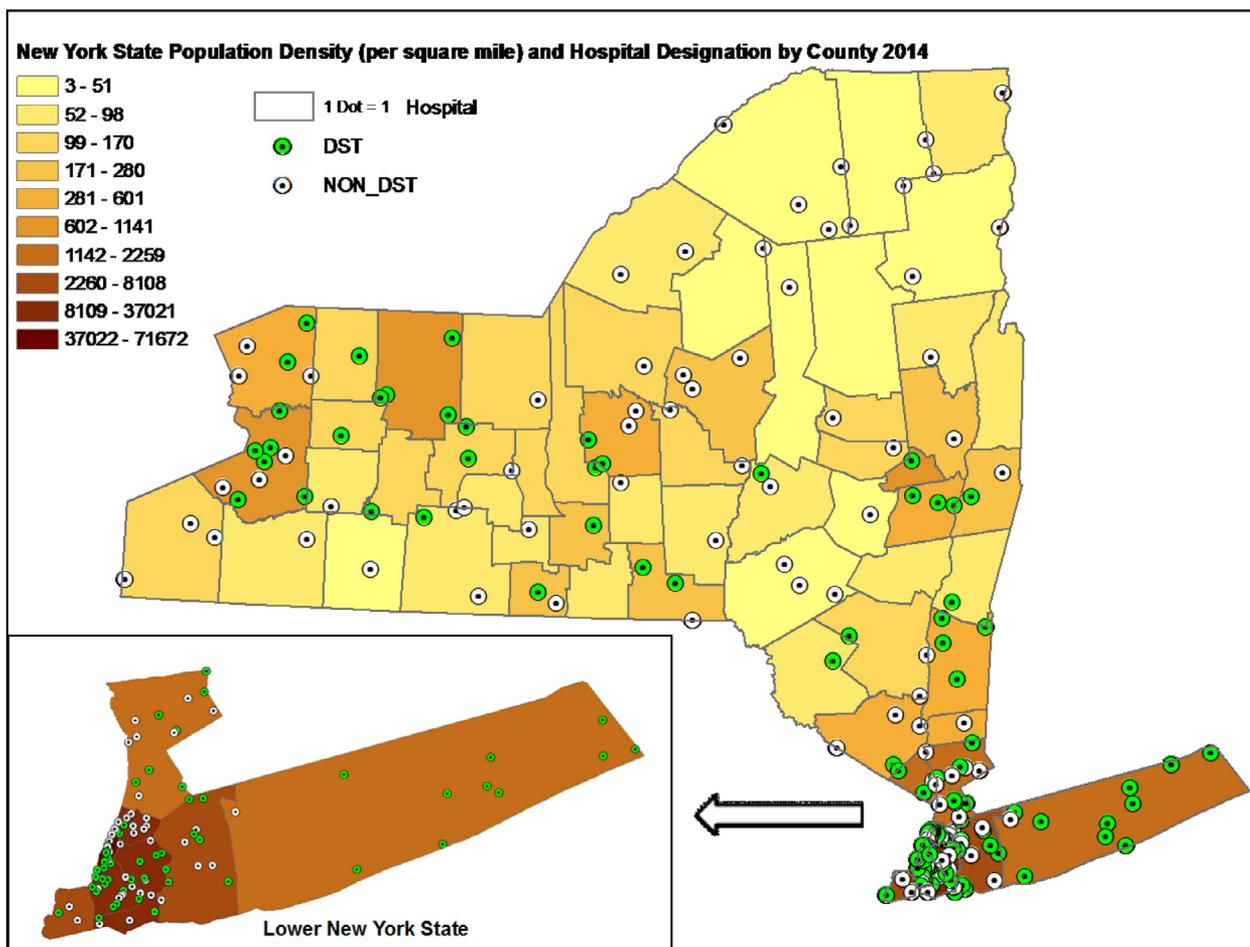


Figure 3. New York state population density and hospital's designation status by County 2014. Abbreviations: DST, designated stroke center; NON-DST, non-designated stroke center.

order interaction term between hospital status and region ($P < .0001$ for both years). Designated stroke centers were associated with increased odds of IV t-PA use, compared to nondesignated stroke centers in Upper NY State in 2010 (OR = 1.94, 95% CI 1.60-2.36, $P < .0001$) and 2014 (OR = 1.93, 95% CI 1.58-2.35, $P < .0001$). The overall rates of IV t-PA utilizations in upper New York State for designated versus nondesignated stroke centers were 5% versus 2.6% in 2010 and 7.21% versus 3.9% in 2014. In lower New York State, admissions to designated stroke centers were associated with lower odds of IV t-PA use compared to nondesignated stroke centers (OR = .81, 95% CI .71-.93, $P = .003$) in 2010. However, this difference was not significant (OR = 1.04, 95% CI .92-1.17, $P = .530$) in 2014. The overall rates of IV t-PA use in lower New York State for designated versus nondesignated stroke centers were 5.1% versus 5.9% in 2010 and 7.2% versus 6.8% in 2014. We did not find differences in IV t-PA use between patients' primary payer type in 2010 ($P = .64$) and in 2014 ($P = .84$). Overall, there was a 26.7% increase of Medicaid recipients and a 7.6% decrease of private insurance holders in stroke-related hospitalizations since 2010. However, IV t-PA utilization rates increased for

all payer groups from 2010 to 2014. The largest increase in IV t-PA use between 2010 and 2014 was for patients' with "no payment" type, increasing by 6.5% (Fig 1).

Discussion

Our study of administrative data from the New York SPARCS explored potential disparities in the administration of IV t-PA in AIS patients. We found an overall increase of approximately 2% in IV t-PA use between 2010 and 2014. However, using 2011 US Medicare Provider and Analysis Review discharge data, Adeoye et al found the IV t-PA administration rate to be only 4% nationally.¹⁷ The percentage of AIS patients potentially eligible to receive IV t-PA in our dataset could not be determined given the data elements available.

IV t-PA Administration Across Demographic Variables

Our findings indicated there was a decrease in the AIS related hospitalizations among Whites from 2010 to 2014. This could be due to White emigration from New York State.^{18,19} One hypothesis that may account for this

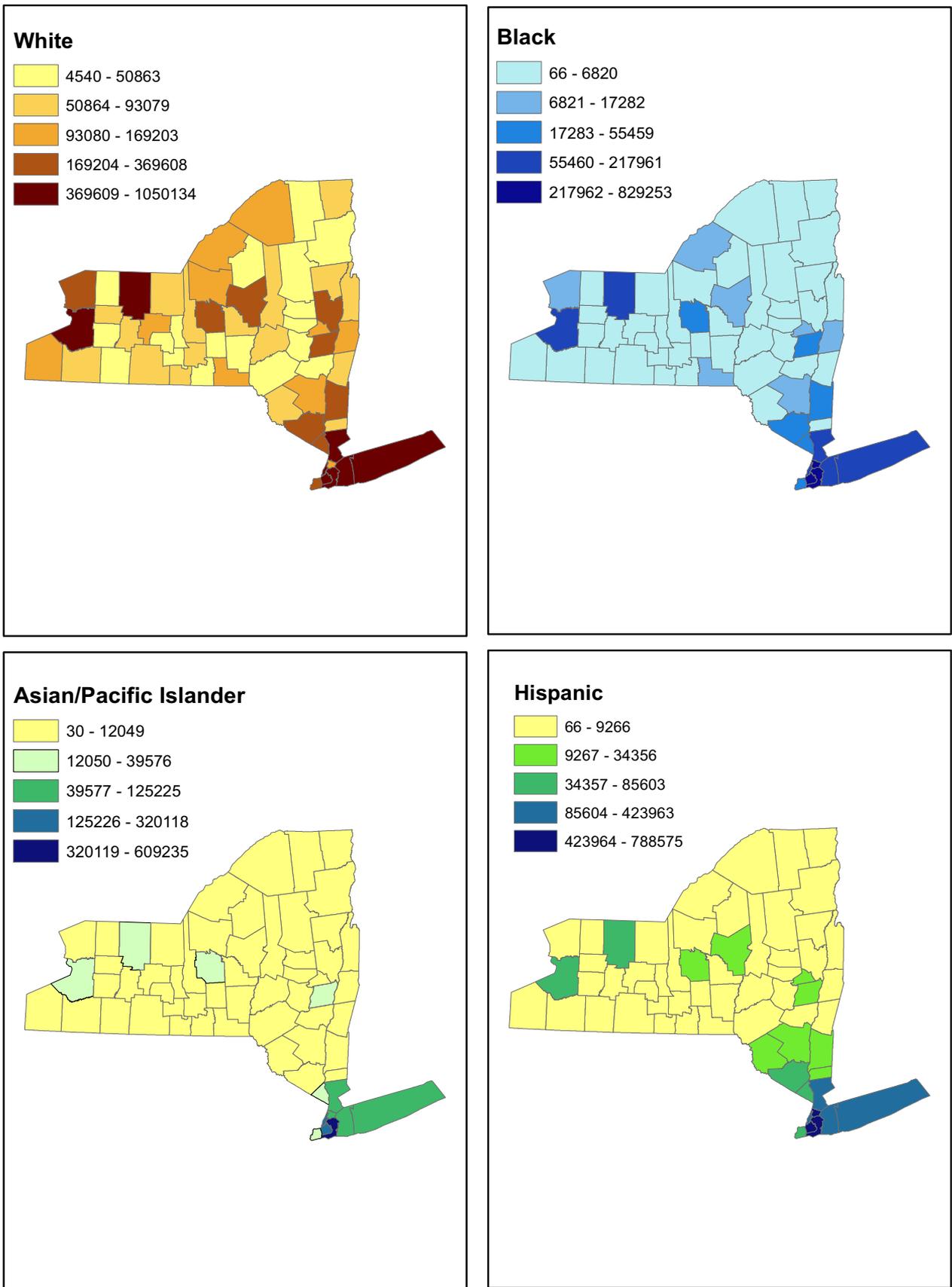


Figure 4. Racial distribution of New York State population by County 2014.

difference is IV t-PA utilization has been found to be higher in Whites, however several studies reported no racial differences if the patient arrives within 2 hours of "last known well time".^{20,21} Inconsistent with previous studies, we found a widening gap in IV t-PA use between Blacks and Whites in 2014, as Blacks were less likely to receive IV t-PA in 2014 than Whites, despite rates being similar in 2010. As suggested by prior studies, this discrepancy may be due to the longer wait times Blacks experience in the emergency department than their White counterparts, which may make them ineligible to receive the time sensitive medication despite presenting to the emergency department in a timely manner.^{22,23} However, previous studies found that Black individuals have an increased risk of disability poststroke, including impairment or loss of activities of daily functioning, when compared to Whites.²⁴ There could be potential biases that consciously or subconsciously influence both the consultant and/or the triaging physician in deciding about t-PA administration upon encounter with the AIS patient. However, administrative SPARCS database does not include information to potentially address these biases.

In a recent analysis of a community-based sample from the *Get with the Guidelines Stroke Program*, women had lower quality of care, as assessed using 7 different measures.²⁵ One of the measures was administration of IV t-PA, which was found to be given significantly more often to men than women. Using the Nationwide Inpatient Sample's large data set (2004-2010) found similar results.⁶ However, in a large study of almost 2000 stroke patients, there were no sex differences.²⁶ Our study also did not find sex to be a significant predictor of IV t-PA use in either 2010 and 2014.

A difference was found in IV t-PA administration by age. Both individuals 61 years old and younger, and over 82 years old received IV t-PA at higher rates than individuals between 62 and 82. Although there is no biological evidence to support this difference, it could be due to chance or potential unstudied/unavailable confounders. We could not confirm this finding from prior studies and the basis for these findings is unclear.

Location and designated stroke center status were also found to predict t-PA administration. Across both time points, designated stroke centers in upper New York State prescribed IV t-PA more often than nondesignated stroke centers in upper New York State. However, in 2010 in lower New York State, designated stroke centers prescribed IV t-PA at lower rates than nondesignated stroke centers and no differences were found in 2014. The reasons for these differences are unclear so further exploration into IV t-PA administration in lower New York State is needed. We could not identify any confounding variables to explain this finding. At both time points, nondesignated stroke centers in lower New York State did not prescribe IV t-PA as often as hospitals in upper New York State. Rural smaller hospitals may be more self-sufficient

for providing IV t-PA than urban, smaller hospitals that can more easily transfer to a stroke center within a shorter distance and time. Population density could also explain these findings (Fig 3), as smaller, rural hospitals may be presented with fewer patients, thus they can more quickly attend to their patients and administer the medication closer to the last known well time.

Limitations

There are several important limitations to our study. Our data consisted only of records from hospitals in New York State, thus findings may not be generalizable to other regions of the United States. In support of generalizability, New York is one of the most diverse states in the United States and the demographic variables of the sample reflected that of the general United States population closer than previous literature. IV t-PA eligibility information of patients who presented to the hospital for AIS were not available in the data set, so it is unclear if the variation in administration was influenced by patients' waiting window.

Our large-scale SPARCS database did not have data on absolute tPA contraindications (eg blood pressure too high, glucose too low or too high, NIHSS score, prior level of functional disability, etc.) and therefore, we were unable to calculate a "t-PA eligible" denominator. The database does not include training background of a practitioner (such as Emergency Department physician, fellow, attending neurologist, attending vascular neurologist, etc.) who actually treated the patient with tPA administration. SPARCS database does not have information on whether telestroke/tele-neurology consultations were performed for consideration of treatment with tPA and therefore, we were unable to address how this mode of treatment would have impacted the study.

The SPARCS data user agreement restricts reporting of aggregated data values that are smaller than 11. Due to this limitation, we chose to visualize data on maps by counties in both upper and lower New York State regions. The unit of data analysis in this study was per individual medical record, not per individual patient, thus, the data could be influenced by a single patient representing multiple data records. However, to our knowledge, no national or state database exists that examines these rates per patient.

Future Directions and Conclusions

Combined with published literature, our findings suggest that discrepancies exist in the administration of IV t-PA. Examples of demographic characteristics include age, race, hospital location, and hospital status (ie, designated stroke center versus nondesignated stroke center). Therefore, medical professionals should be aware of the possible biases they may hold and ensure that they are assessing patients based on symptoms, and

medical judgment not impacted by patient characteristics. However, a greater understanding of which variables have the greatest influence disparities in treatment needs to be assessed. Future research should include a more comprehensive sample across the United States, assessing for all hypothesized influential demographic characteristics at once. Though IV t-PA administration is increasing, further awareness of discrepancies is warranted in order to ensure optimal patient care provided to stroke patients, thus improving outcomes in an already vulnerable population.

Supplementary Material

Supplementary data to this article can be found online at [doi:10.1016/j.jstrokecerebrovasdis.2019.01.013](https://doi.org/10.1016/j.jstrokecerebrovasdis.2019.01.013).

References

1. Ma VY, Chan L, Carruthers KJ. Incidence, prevalence, costs, and impact on disability of common conditions requiring rehabilitation in the United States: stroke, spinal cord injury, traumatic brain injury, multiple sclerosis, osteoarthritis, rheumatoid arthritis, limb loss, and back pain. *Arch Phys Med Rehab* 2014;95:986-995.
2. Nelson AR. Unequal treatment: confronting racial and ethnic disparities in health care. *J Natl Med Assoc* 2002;94:666-668.
3. Boehme AK, Siegler JE, Mullen MT, et al. Racial and gender differences in stroke severity, outcomes and treatment in patients with acute ischemic stroke. *J Stroke Cerebrovasc Dis* 2014;23:e255-e261.
4. Chen PM, Nguyen DT, Ho JP, et al. Factors influencing acute stroke thrombolytic treatments in hispanics in the San Diego region. *Austin J Cerebrovasc Dis Stroke* 2018;5(1):1074.
5. Gonzales S, Mullen MT, Skolarus L, et al. Progressive rural-urban disparity in acute stroke care. *Neurology* 2017;88:441-448.
6. Boehme AK, Carr BG, Kasner SE, et al. Sex differences in rt-PA utilization at hospitals treating stroke: the national inpatient sample. *Front Neurol* 2017;8:500.
7. Ponder C, Silvestri S, Hunter C. Significant improvements in "Door-To-CT" "Door-To-t-PA" times and frequency of t-PA given when a stroke center transitions from primary to comprehensive. *Ann Emerg Med* 2016;68:S102.
8. Hutton CF, Fleming J, Youngquist S, et al. Stroke and helicopter emergency medical service transports: an analysis of 25,332 patients. *Air Med J* 2015;34:348-356.
9. Rajan SS, Baraniuk S, Parker S, et al. Implementing a mobile stroke unit program in the United States: why, how, and how much? *JAMA Neurol* 2015;72:229-234.
10. Sabayan B, Gussekloo J, de Ruijter W, et al. Framingham stroke risk score and cognitive impairment for predicting first-time stroke in the oldest old. *Stroke* 2013;44:1866-1871.
11. Kite ME, Stockdale GD, Whitley BE, et al. Attitudes toward younger and older adults: an updated meta-analytic review. *J Soc Issues* 2005;61:241-266.
12. Statewide Planning and Research Cooperative System (SPARCS). Bureau of health informatics, office of quality and patient safety, New York State Department of Health. <https://www.health.ny.gov/statistics/sparcs/>. Accessed November 11, 2017.
13. New York State Department of Health. NYS Health Profiles. https://profiles.health.ny.gov/hospital/designated_centers/Stroke+Center. Accessed September 20, 2018.
14. Alberts MJ, Hademenos G, Latchaw RF, et al. Recommendations for the establishment of primary stroke centers. *JAMA* 2000;283:3102-3109.
15. Gropen T, Gagliano PJ, Blake CA, et al. Quality improvement in acute stroke: the New York state stroke center designation project. *Neurology* 2006;67:88-93.
16. New York State Department of Health. Vital Statistics of New York State. https://www.health.ny.gov/statistics/vital_statistics/. Accessed December 20, 2018.
17. Adeoye O, Hornung R, Khatri P, et al. Recombinant tissue-type plasminogen activator use for ischemic stroke in the United States: a doubling of treatment rates over the course of 5 years. *Stroke* 2011;42:1952-1955.
18. Census Viewer. Population of New York: census 2010 and 2000 interactive map, demographics, statistics, quick facts. <http://censusviewer.com/state/NY>. Accessed September 27, 2018.
19. New York State Department of Health. New York State health indicators by race/ethnicity, 2012-2014. website. <https://www.health.ny.gov/statistics/community/minority/county/newyorkstate.htm>. Accessed September 27, 2018.
20. Hsia AW, Edwards DF, Morgenstern LB, et al. Racial disparities in tissue plasminogen activator treatment rate for stroke. *Stroke* 2011;42:2217-2221.
21. Nasr DM, Brinjikji W, Cloft HJ, et al. Racial and ethnic disparities in the use of intravenous recombinant tissue plasminogen activator and outcomes for acute ischemic stroke. *J Stroke Cerebrovasc Dis* 2013;22:154-160.
22. Lacy CR, Suh DC, Bueno M, et al. Delay in presentation and evaluation for acute stroke: stroke time registry for outcomes knowledge and epidemiology (STROKE) *Stroke* 2001;32:63-69.
23. Karve SJ, Balkrishnan R, Mohammad YM, et al. Racial/Ethnic disparities in emergency department waiting time for stroke patients in the United States. *J Stroke Cerebrovasc Dis* 2011;20:30-40.
24. Burke JF, Skolarus LE, Freedman VA. Abstract T P131: racial disparities in post-stroke activity limitations are not due to pre-stroke activity limitation differences. *Stroke* 2015;46. ATP131 (abstract).
25. McDermott M, Lisabeth LD, Baek J, et al. Sex disparity in stroke quality of care in a community-based study. *J Stroke Cerebrovasc Dis* 2017;26:1781-1786.
26. Bushnell CD, Reeves MJ, Zhao X, et al. Sex differences in quality of life after ischemic stroke. *Neurology* 2014;82:922-931.