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and Risk Factors

Race-Ethnic Disparities in Hospital Arrival Time after Ischemic Stroke

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Objective: Conflicting reports exist about hospital arrival time after stroke onset in Hispanics compared with African Americans and Caucasians. Our current study investigates race-ethnic disparities in hospital arrival times after stroke onset.

Methods: We performed a retrospective analysis of hospital arrival times in Hispanic, African American, and Caucasian acute ischemic stroke patients (N=1790) presenting to a tertiary-care hospital in the Bronx, New York. A multivariable logistic regression model was used to identify the association between race-ethnicity and hospital arrival time adjusting for age, sex, socioeconomic status (SES), NIH stroke scale (NIHSS), history of stroke, preferred language and transportation mode to the hospital.

Results: There were 338 Caucasians, 662 Hispanics, and 790 African Americans in the cohort. Compared with Caucasians, African Americans and Hispanics were younger (P<.0001 respectively), had lower SES (P<.001 respectively) and were less likely to use EMS (P=.003 and P=.001, respectively). A greater proportion of Hispanic and African American women had delayed hospital arrival times (≥3 hours) after onset of stroke symptoms compared with Caucasian women (74% of Hispanic, 72% of African American, and 59% of Caucasian women), but this difference between race-ethnicities is no longer present after adjusting for socioeconomic status. Compared with Caucasian men, hospital arrival ≥3 hours after symptom onset was more likely for African American men (OR 1.72, 95% CI:1.05-2.79) but not Hispanic men (OR .80, 95% CI .49-1.30).

Conclusions: African American men and socially disadvantaged women delay in presenting to the hospital after stroke onset. Future research should focus on identifying the factors contributing to pre-hospital delay among race-ethnic minorities. *Ethn Dis.* 2017;27(2):125-132; doi:10.18865/ed.27.2.125.

Keywords: Stroke; Health Care Disparities; Race; Hispanics; Delay; African Americans

Background

Stroke is the leading preventable cause of disability worldwide. Tissue plasminogen activator (tPA) is an acute stroke treatment that reduces disability after stroke. However, a low percentage of stroke patients are treated with tPA each year with estimates as low as 7%,[1] in part because many patients do not arrive in time to be eligible for treatment.[2] African Americans have a higher stroke incidence than Caucasians, but are less likely to receive tPA treatment that can reduce their disability from stroke.[3-7] African American patients are less likely than Caucasians to arrive within the 3-hour tPA treatment window.[5,8-10]

Hispanics also have higher stroke incidence than Caucasians,[11,12] but some studies suggest that they are less likely than Caucasians to receive tPA for acute stroke.[3,7] Many studies on race-ethnic variations in tPA treatment have either included small numbers of Hispanics or excluded them completely.[4-6] The reason for the discrepancy in treatment with tPA between Hispanics and Caucasians remains unexplored.

One possibility for the treatment disparity in Hispanics is a delay in hospital arrival as has been shown in African Americans. In a recent study examining the effect of an educational program on hospital arrival times after onset of symptoms of stroke or TIA,[13] 51% of the study participants were Hispanic. The proportion of Hispanics who arrived within 3 hours of symptom onset prior to the educational intervention was similar to the proportion of early arriving Caucasian patients (27% Hispanic vs 28% White). Whether this finding applies to other Hispanic populations is not clear, because the arrival time after symptom onset in African Americans was also similar to Caucasians in this study (26% of African Americans arrived within 3 hours) suggesting that the Hispanics and African Americans in this sample were

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more similar to the Caucasians than in other studies. In a different study that included only Hispanics and Caucasians, hospital arrival times after onset of stroke symptoms did not differ between the groups.[14] In contrast, other investigators have shown a trend for earlier hospital arrival after symptom onset in Mexican Americans compared with Caucasians.[15] To reconcile these conflicting reports, additional studies on hospital arrival time after onset of stroke symptoms in Hispanics are needed. Our current study investigates disparities in hospital arrival times among Hispanics and African Americans vs Caucasians after stroke symptom onset.

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Methods

We conducted a retrospective analysis of acute ischemic stroke patients hospitalized at an urban academic hospital in Bronx, New York from January 1, 2012- December 31, 2015. Patients aged >17 years were ascertained by discharge ICD 9 / ICD 10 code for ischemic stroke, which was then confirmed by chart review. Demographic and clinical information was obtained through hospital records. Patients residing in a health care facility, transferred from an outside hospital, or who had a stroke while hospitalized were excluded. Patients who identified as a race or ethnicity other than Hispanic, Caucasian, or African American were excluded from the sample. In addition, patients who were alone and too disabled to seek help on their own, or who awoke with their symptoms were also excluded. The project was deemed exempt from the need to obtain patient consent by the local institutional review board.

Data analysis was performed using STATA software, version 14. Sociodemographic covariates included age in years, race or ethnicity (African American, Caucasian, or Hispanic), sex, and socioeconomic status (SES). To facilitate comparison with previous studies, Hispanic White and Hispanic Black were categorized as Hispanic. Race/ethnicity is self-reported by the patient or family. The patient's age in years was retained as a continuous variable. Using the patient's home ZIP code to identify the patient's census block, socioeconomic status (SES) was a variable that used census block information to determine 1) log of median household income; 2) log of median value of housing units; 3) the percentage of households receiving interest, dividend, or net rental income; 4) the percentage of adults aged >25 years who completed high school; 5) the percentage of adults who completed college; and 6) the percentage of employed individuals in executive, managerial, or professional positions. A z-score for each of the 6 variables was created using the New York State average as the comparison group. The six z-scores were combined to generate a single z-score representing the patient's socioeconomic status.[16] The z-scores for the population were divided into quartiles, with increasing quartiles representing higher SES. The patient's preferred language of communication was self-reported. If the patient reported a preferred language other than English or Spanish, the value was set to missing. Clinical covariates included prior history of stroke and NIH stroke scale (NIHSS), which is scored from 0 to 42 with higher numbers indicating more severe stroke signs. The NIHSS is scored by the neurology physician who first examines the patient upon hospital arrival. If the NIHSS was not documented, it was calculated post-hoc by chart review of the patient's documented neurological exam upon hospital arrival.[17] The patient's mode of hospital arrival was an additional covariate that was categorized as ambulance vs private transportation. The outcome of interest was time between symptom onset and hospital arrival that was dichotomized into <3 hours vs ≥3 hours. The time of symptom onset was originally obtained by the neurology physician who first interviewed the patient and was documented in the electronic medical record. If the patient was not sure of the time of onset, the time the patient was last known to be well was used as the time of onset. Hospital arrival time is the time at which the patient is triaged in the emergency department. Race/

ethnicity was the exposure of interest and was coded as a dummy variable using Caucasian race as the reference.

Missing data were excluded from analyses.

Characteristics of the sample were summarized using a mean and standard deviation for continuous variables that were normally distributed. The median and interquartile range was used to summarize continuous variables that deviated from the normal distribution. Categorical variables were summarized with frequencies and percentages.

Bivariate associations between race and each independent variable was assessed. The relationship between a continuous independent variable and race was assessed with ANOVA when the assumptions of normality and equal variances were met. Normality was evaluated by visual inspection of the histogram for that variable. Equality of variance was assessed with Levene's robust test statistic for equality of variances. If the continuous independent variable did not appear normally distributed, the Kruskal-Wallis test was used. The relationship between categorical independent variables and race/ethnicity (consisting of 3 levels, Caucasian, African American and Hispanic) was assessed with the chi-square test. If the association was found to be statistically significant at P <.05, the race/ethnicity variable was then dichotomized and separate 2 x 2 chi square tests were performed between race/ethnicity (eg, African American vs Caucasian, African American vs Hispanic, Caucasian vs Hispanic) and the independent variable. Bonferroni correction was made for multiple testing with significance set at P=.017, which equals .05 divided by 3, [the number of comparisons]).

A multivariable logistic regression model (model 1) was constructed using time between symptom onset and hospital arrival (<3 hours vs ≥3 hours) as the dependent variable. All independent variables that had a bivariate association with race at P<.05 were included as covariates. Variables that had an association with arrival time at a P<.05 were retained in the full model but age, sex, and NIHSS were included in the final model regardless of the statistical significance. Variables identified as confounders were also retained in the full model. Confounding was evaluated by removing independent variables individually from the full model. If there was a 15% or greater change in the b coefficient of race with removal of an independent variable, that variable was considered to be a confounder and was included in the full model.[18]

Interactions between race and selected independent variables were evaluated. Only independent variables that could have a potentially clinically significant interaction with race were evaluated. P<.1 was interpreted as being suggestive of interaction and the model was stratified on the independent variable. An additional multivariable logistic regression model was constructed (model 2) excluding SES to determine how SES influences the association between race-ethnicity and time of hospital arrival. A post-hoc analysis was performed to evaluate whether patients included in the multivariable regression analysis (ie, patients who had data on all covariates and the outcome) differed from patients who were excluded from the multivariable regression analysis. The final multivariable model was evaluated for influential and outlying values by assessing covariate patterns that had values of delta chi-squared >4, delta-beta >.3, and delta-deviance >4.

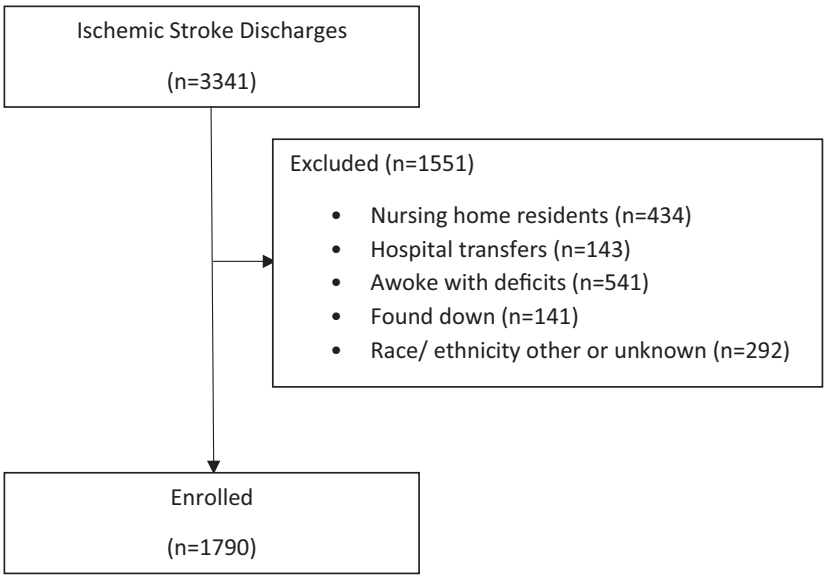

Figure 1. Excluded patients

Results

There were 1790 people included in the sample. Figure 1 shows the number of patients excluded based on the aforementioned exclusionary criteria. Of the 1790 patients included in the cohort, 161 patients had missing data on time of symptom onset and were excluded from the analysis. A total of 300 patients were not included in the final multivariable model due to missing data on at least one of the covariates or on the outcome. For example, 131 patients were missing data on SES (68 women and 63 men).

The bivariate associations between race/ethnicity and the other covariates of interest are presented in Table 1. P-values for post-hoc two group comparisons are not shown in the table, but are indicated in parentheses in the text below. The race-ethnic breakdown of the sample is approximately 19% Caucasian, 37% Hispanic, and 44% African American. Caucasians were older than African Americans (P<.001) and Hispanics (P<.001) in this population. 47% of Hispanics preferred to communicate in Spanish compared with 1% of African Americans (P<.001) and 1% of Caucasians (P<.001). The proportion of males and females did not significantly differ between race-ethnicities (P=.05). Caucasians had higher SES than Hispanics (P<.001) and African Americans (P<.001). A greater proportion of Caucasians than Hispanics (P=.001) and African Americans (P=.003) used EMS for transportation to the hospital vs using private transportation. There was no statistically significant difference between African Americans and Hispanics in the mode of transportation used to get to the hospital (P=.61). More African Americans and Hispanics had a prior history of stroke compared with Caucasians (P=.001 and P<.001, respectively). There was no statistically significant difference between the proportion of African Americans and Hispanics with a prior history of stroke (P=.46).

The majority of patients had mild strokes with median NIHSS ≤5 in all race-ethnic groups. Specifically, 66% of Caucasians, 72% of Hispanics, and 69% of African Americans had a NIHSS of ≤5. NIHSS values were retrospectively calculated by the investigator for 55% of patients. A different investigator retrospectively calculated 10% of the missing NIHSS values. There was almost perfect agreement between the two investigators in the retrospective calculation of the NIHSS (Cohen's Kappa=.88). In the unadjusted model (Table 2), more African American and Hispanic women delayed in hospital arrival compared with Caucasian women (P=.003 and P=.001, respectively). 72% of African American women, 74% of Hispanic women, and 59% of Caucasian women arrived ≥3 hours after symptom onset. For men, African Americans were more likely to delay than Caucasians (75% of African American vs 62% of Caucasian men arrived ≥3 hours; P=.003). There was no significant difference in time of hospital arrival between Hispanic and Caucasian men (64% of Hispanic vs 62% of Caucasian men arrived ≥3 hours; P=.72).

The independent variables in-

Table 1. Sociodemographic and clinical characteristics of acute ischemic stroke patients by race-ethnicity, N=1790

	Caucasian, n=338	Hispanic, n=662	African American, n=790	P
Age, years	75 ± 14	68 ± 15	67 ± 14	<.0001
Women	166 (49%)	344 (52%)	446 (56%)	.05
Mode of arrival				.003
EMS	250 (75%)	425 (65%)	518 (66%)	
Private	83 (25%)	230 (35%)	265 (34%)	
SES				<.001
1st quartile	27 (9%)	209 (34%)	168 (23%)	
2nd quartile	42 (14%)	197 (32%)	197 (27%)	
3rd quartile	97 (33%)	143 (23%)	238 (32%)	
4th quartile	132 (44%)	71 (11%)	138 (19%)	
Prior stroke	75 (22%)	225 (34%)	254 (32%)	<.001
NIHSS	3 (1-8)	3 (1-6)	3 (1-7)	.53

Data are presented as means ± standard deviations, medians (interquartile range) or n (%).
EMS, emergency medical services; NIHSS, National Institutes of Health stroke scale; SES, socioeconomic status.

Table 2. Relationship between race-ethnicity and hospital arrival time in women and men

	Caucasian	Hispanic	African-American	Omnibus P
Women	n=159	n=307	n=397	.02
N (%) arriving in <3 hrs	65 (41)	80 (26)	110 (28)	
N (%) arriving in ≥3 hrs	94 (59)	227 (74)	287 (72)	
Men:	n=162	n=295	n=309	.002
N (%) arriving in <3 hrs	61 (38)	106 (36)	76 (25)	
N (%) arriving in ≥3 hrs	101 (62)	189 (64)	233 (75)	

cluded in the final multivariable model were age, race, mode of transportation to the hospital, NIH stroke scale, and socioeconomic status. There were no outlying or influential covariate patterns identified in the final regression model. The variables of past history of stroke and preferred language were not confounders of the association between race and time of hospital arrival when adjusted for the other covariates in the model and were therefore excluded from the model. The association between race and time of hospital arrival did not depend on the patient's age (P=.66). There was a statistically significant interaction between sex and race (P=.02). The model was therefore stratified by sex. Tables 3 and 4 show the multivariable logistic regression analyses for women and men respectively. Univariate estimates for the relationship between each variable and time of hospital arrival (<3 hours vs ≥3 hours) are also shown in Tables 3 and 4. African American and Hispanic women did not differ from Caucasian women (P=.2 for each comparison) in time of hospital arrival after stroke symptom onset when adjusted for age, stroke severity, EMS use, and SES (Table 3, model 1). African American men were 72% more likely to arrive 3 hours or later from symptom onset compared with Caucasian men (P=.03; Table 4, model 1). There was no significant difference between Hispanic men and Caucasian men in time to hospital arrival (P=.36; Table 4, model 1). Excluding socioeconomic status from the model (model 2 in Tables 3 and 4), Hispanic (P=.027) and African American (trend of P=.056) women delay compared with Caucasian women. For men, the inferences are the same as when SES is included.

Patients who were excluded from the final multivariable model used EMS slightly less for hospital transport than included patients (P=.047; 62% of the excluded vs 68% of the included group used EMS). All other baseline characteristics including race-ethnic distribution and hospital arrival within 3 hours of symptom onset were similar between included and excluded patients.

Table 3. Women: multivariable logistic regression model for hospital arrival ≥ 3 hours from symptom onset, N=790

	Univariate OR (95% CI)	Multivariable: Model 1 OR (95% CI)	Multivariable: Model 2 OR (95% CI)
Age	.99 (.98-1.00)	1.01 (.99-1.02)	1.01 (.99-1.02)
Race/Ethnicity			
Caucasian	reference	reference	
Hispanic	1.96 (1.31-2.94) [a]	1.39 (0.86-2.24)	1.67 (1.06-2.63) [a]
African American	1.80 (1.23-2.65) [a]	1.37 (0.88-2.15)	1.53 (.99-2.35) [b]
EMS use	4.10 (2.77-6.07) [a]	3.66 (2.37-5.64) [a]	3.60 (2.34-5.54) [a]
NIHSS	.93 (.91-.96) [a]	.96 (.94-.99) [a]	.96 (.94-.99) [a]
SES			
1st quartile	reference	reference	
2nd quartile	.79 (.50-1.25)	0.82 (0.51-1.33)	---
3rd quartile	.62 (.40-.95) [a]	0.65 (0.41-1.03)	---
4th quartile	.49 (.31-.78) [a]	0.53 (0.32-0.88) [a]	---

EMS, emergency medical services; NIHSS, national institutes of health stroke scale; SES, socioeconomic status.
a. P<.05
b. P=.056.

Discussion

The novel contribution of the current study is that a greater proportion of Hispanic and African American women delay in hospital arrival after onset of stroke symptoms compared with Caucasian women, but this difference between race-ethnicities is no longer statistically significant after adjusting for SES. Our findings suggest that SES in women may be more important than race-ethnicity in determining time of arrival after stroke. A prior study showed that Mexican American women did not differ in time of hospital arrival compared with Caucasian women after adjusting for insurance, education and other clinical and demographic variables.[15] In a study that did not adjust for SES, African American women were less likely to arrive within 3 hours of symptom onset compared with all other patients.[4] Prior studies have used education or insurance as a proxy for SES and have not found SES to be independently associated with delay in hospital arrival.[8-10] The six variables combined to represent SES in this study were derived from factor analysis of data from census blocks[16] and therefore may be a better representation of economic and social position than insurance status. Perhaps the influence of SES on hospital arrival is mediated by health literacy. The ability to obtain, process, and understand basic health information and services is central to making appropriate health decisions.[19] Both non-Caucasian ethnicity and low level of education have been associated with low levels of health literacy.[20] Non-Caucasians had lower SES in this sample. Poorer health literacy in non-Caucasian women might be a possible explanation for the observed association between SES and delay in hospital arrival.

Our study adds to prior research showing no difference in hospital arrival between Hispanic and Caucasian men,[15] but delayed arrival in African American men.[5,10,21] Although higher SES was independently associated with early arrival, the relationship between race-ethnicity and delay in African American men remained even after adjusting for SES. Perhaps African American men are more likely than Hispanics and Caucasians to possess attitudes and behaviors that result in delayed hospital arrival. Perceived control of symptoms, not perceiving symptoms as serious, and waiting for symptoms to resolve have all been associated with delay after onset of stroke symptoms.[22,23] More research is needed to determine the factors that contribute to the observed race-ethnic variation in delay.

Pre-hospital delay in Hispanic men and women differed in our study. In a cohort of stroke patients in Texas, Mexican American men showed a trend for faster hospital arrival than their female counterparts.[15] Although men and women were not directly compared in our study, Hispanic women demonstrated pre-hospital delay in the unadjusted model but Hispanic men did not. Being married or living with a partner has been shown as an important determinant of early hospital arrival.[24] Information about marital status was not available for the participants of our study.

Table 4. Men: multivariable logistic regression model for hospital arrival ≥ 3 hours from symptom onset, N=700

	Univariate OR (95% CI)	Multivariable: Model 1 OR (95% CI)	Multivariable: Model 2 OR (95% CI)
Age	.99 (.98-1.01)	1.01 (.99-1.02)	1.01 (.99-1.02)
Race/Ethnicity			
Caucasian	reference	reference	
Hispanic	1.08 (.72-1.60)	.80 (.49-1.30)	1.02 (.65-1.62)
African American	1.85 (1.23-2.79)[a]	1.72 (1.05-2.79)[a]	1.99 (1.24-3.19)[a]
EMS use	3.50 (2.38-5.15)[a]	3.02 (1.96-4.67)[a]	3.01 (1.95-4.63)[a]
NIHSS	.91 (.89-.94)[a]	.93 (.90-.96)[a]	.93 (.91-.96)[a]
SES			
1st quartile	reference	reference	---
2nd quartile	.78 (.48-1.26)	.71 (.42-1.19)	---
3rd quartile	.54 (.34-.85)[a]	.45 (.27-.74)[a]	---
4th quartile	.55 (.33-.89)[a]	.49 (.28-.85)[a]	---

EMS, emergency medical services; NIHSS, national institutes of health stroke scale; SES, socioeconomic status.
a. P<.05.

Perhaps more Hispanic men were married or living with a partner than Hispanic women in this study, thereby leading to faster hospital arrival than their female counterparts.

Arrival by ambulance is another factor that has been consistently associated with early hospital arrival after stroke onset.[2,8,9,21,25-27] Accordingly, we found that women using EMS were 3.7 times and men were 3.0 times more likely to arrive to the hospital early. In this study, more Caucasians than Hispanics and African Americans called 911 rather than used private transportation, as has been reported previously.[14,21] The association between race-ethnicity and delay in hospital arrival in this sample remained significant even after adjusting for EMS use, suggesting that factors other than EMS use contribute to pre-hospital delay in African American men and Hispanic women.

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This study has limitations. First, 17% of patients were excluded from the multivariable model due to missing data. However, the race-ethnic distribution and the majority of baseline characteristics of excluded patients did not differ from included patients. It is possible that adjusting for SES eliminated the race-ethnic disparity in hospital arrival time in women, because missing data on this variable reduced the sample size. However a similar number of men were missing data on the SES variable and adjustment for SES in men did not alter the association between African American race and delay in arrival. Second, 55% of NIH stroke scale values were retrospectively determined by the investigator from an examination performed by a neurology resident upon presentation. However, this approach has been validated previously.[17] Furthermore, the values obtained by two independent scorers showed almost perfect agreement. Third, our findings may not be generalizable to stroke patients who live in non-urban populations.

In summary, African American men are less likely to arrive at the hospital within 3 hours of stroke symptom onset. The effect of SES appears to be more important than race-ethnicity in women in predicting pre-hospital delay. Additional research is needed to identify the barriers to early hospital arrival in African American men and socially disadvantaged women so that the content of educational campaigns can focus on those aspects of stroke preparedness that are likely to lead to behavioral change.

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Conflict of Interest

No conflicts of interest to report.

Author Contributions

Research concept and design: Springer, Labovitz; Acquisition of data: Springer, Hochheiser; Data analysis and interpretation: Springer, Hochheiser; Manuscript draft: Springer, Labovitz; Statistical expertise: Springer; Acquisition of funding: Springer; Administrative: Hochheiser; Supervision: Springer, Labovitz

References

1. Schwamm LH, Reeves MJ, Pan W, et al. Race/ethnicity, quality of care, and outcomes in ischemic stroke. *Circulation*. 2010;121(13):1492-1501. https://doi.org/10.1161/CIRCULATIONAHA.109.881490. PMID:20308617.
2. Tong D, Reeves MJ, Hernandez AF, et al. Times from symptom onset to hospital arrival in the Get with the Guidelines--Stroke Program 2002 to 2009: temporal trends and implications. *Stroke*. 2012;43(7):1912-1917. https://doi.org/10.1161/STROKEAHA.111.644963. PMID:22539544.
3. Nasr DM, Brinjikji W, Cloft HJ, Rabinstein AA. 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(2):154-160. https://doi.org/10.1016/j.jstrokecerebrovasdis.2011.07.003. PMID:22155116.
4. 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(4):e255-e261. https://doi.org/10.1016/j.jstrokecerebrovasdis.2013.11.003. PMID:24468069.
5. Hsia AW, Edwards DF, Morgenstern LB, et al. Racial disparities in tissue plasminogen activator treatment rate for stroke: a population-based study. *Stroke*. 2011;42(8):2217-2221. https://doi.org/10.1161/STROKEAHA.111.613828. PMID:21719765.
6. Johnston SC, Fung LH, Gillum LA, et al. Utilization of intravenous tissue-type plasminogen activator for ischemic stroke at academic medical centers: the influence of ethnicity. *Stroke*. 2001;32(5):1061-1068. https://doi.org/10.1161/01.STR.32.5.1061. PMID:11340210.

7. Aparicio HJ, Carr BG, Kasner SE, et al. Racial disparities in intravenous recombinant tissue plasminogen activator use persist at primary stroke centers. *J Am Heart Assoc*. 2015;4(10):e001877. https://doi.org/10.1161/JAHA.115.001877. PMID:26467999.
8. Lichtman JH, Watanabe E, Allen NB, Jones SB, Dostal J, Goldstein LB. Hospital arrival time and intravenous t-PA use in US Academic Medical Centers, 2001-2004. *Stroke*. 2009;40(12):3845-3850. https://doi.org/10.1161/STROKEAHA.109.562660. PMID:19797697.
9. Lacy CR, Suh DC, Bueno M, Kostis JB. Delay in presentation and evaluation for acute stroke: Stroke Time Registry for Outcomes Knowledge and Epidemiology (S.T.R.O.K.E.). *Stroke*. 2001;32(1):63-69. https://doi.org/10.1161/01.STR.32.1.63. PMID:11136916.
10. Siegler JE, Boehme AK, Albright KC, Martin-Schild S. Ethnic disparities trump other risk factors in determining delay to emergency department arrival in acute ischemic stroke. *Ethn Dis*. 2013;23(1):29-34. PMID:23495619.
11. Morgenstern LB, Smith MA, Lisabeth LD, et al. Excess stroke in Mexican Americans compared with non-Hispanic Whites: the Brain Attack Surveillance in Corpus Christi Project. *Am J Epidemiol*. 2004;160(4):376-383. https://doi.org/10.1093/aje/kwh225. PMID:15286023.
12. White H, Boden-Albala B, Wang C, et al. Ischemic stroke subtype incidence among whites, blacks, and Hispanics: the Northern Manhattan Study. *Circulation*. 2005;111(10):1327-1331. https://doi.org/10.1161/01.CIR.0000157736.19739.D0. PMID:15769776.
13. Boden-Albala B, Stillman J, Roberts ET, et al. Comparison of acute stroke preparedness strategies to decrease emergency department arrival time in a multiethnic cohort: the stroke warning information and faster treatment study. *Stroke*. 2015;46(7):1806-1812. https://doi.org/10.1161/STROKEAHA.114.008502. PMID:26069259.
14. Neil WP, Raman R, Hemmen TM, et al. Association of Hispanic ethnicity with acute ischemic stroke care processes and outcomes. *Ethn Dis*. 2015;25(1):19-23. PMID:25812247.
15. Smith MA, Lisabeth LD, Bonikowski F, Morgenstern LB. The role of ethnicity, sex, and language on delay to hospital arrival for acute ischemic stroke. *Stroke*. 2010;41(5):905-909. https://doi.org/10.1161/STROKEAHA.110.578112. PMID:20339124.
16. Diez Roux AV, Merkin SS, Arnett D, et al. Neighborhood of residence and incidence of coronary heart disease. *N Engl J Med*. 2001;345(2):99-106. https://doi.org/10.1056/NEJM200107123450205. PMID:11450679.
17. Kasner SE, Chalela JA, Luciano JM, et al. Reliability and validity of estimating the NIH stroke scale score from medical records. *Stroke*. 1999;30(8):1534-1537. https://doi.org/10.1161/01.STR.30.8.1534. PMID:10436096.
18. Hosmer DW, Lemeshow S, Sturdivant RX. *Applied Logistic Regression*. Hoboken, NJ: Wiley & Sons. 2013.
19. Ratzan SC, Parker RM. Introduction. In: Selden CR e, Zorn M, eds. *National Library of Medicine Current Bibliographies in Medicine: Health Literacy*. Bethesda, MD: National Institutes of Health, U.S. Department of Health and Human Services; 2000.
20. Paasche-Orlow MK, Parker RM, Gazmararian JA, Nielsen-Bohlman LT, Rudd RR. The prevalence of limited health literacy. *J Gen Intern Med*. 2005;20(2):175-184. https://doi.org/10.1111/j.1525-1497.2005.40245.x. PMID:15836552.
21. Kothari R, Jauch E, Broderick J, et al. Acute stroke: delays to presentation and emergency department evaluation. *Ann Emerg Med*. 1999;33(1):3-8. https://doi.org/10.1016/S0196-0644(99)70431-2. PMID:9867880.
22. Hsia AW, Castle A, Wing JJ, et al. Understanding reasons for delay in seeking acute stroke care in an underserved urban population. *Stroke*. 2011;42(6):1697-1701. https://doi.org/10.1161/STROKEAHA.110.604736. PMID:21546471.
23. Mandelzweig L, Goldbourt U, Boyko V, Tanne D. Perceptual, social, and behavioral factors associated with delays in seeking medical care in patients with symptoms of acute stroke. *Stroke*. 2006;37(5):1248-1253. https://doi.org/10.1161/01.STR.0000217200.61167.39. PMID:16556885.
24. Boden-Albala B, Tehranifar P, Stillman J, Paik MC. Social network types and acute stroke preparedness behavior. *Cerebrovasc Dis Extra*. 2011;1(1):75-83. https://doi.org/10.1159/000328726. PMID:22566985.
25. Barsan WG, Brott TG, Broderick JP, Haley EC, Levy DE, Marler JR. Time of hospital presentation in patients with acute stroke. *Arch Intern Med*. 1993;153(22):2558-2561. https://doi.org/10.1001/archinte.1993.00410220058006. PMID:7598755.
26. Rosamond WD, Gorton RA, Hinn AR, Hohenhaus SM, Morris DL. Rapid response to stroke symptoms: The Delay in Accessing Stroke Healthcare (DASH) study. *Academ Emerg Med*. 1998;5:45-51.
27. Madsen TE, Sucharew H, Katz B, et al. Gender and time to arrival among ischemic stroke patients in the greater Cincinnati/northern Kentucky stroke study. *J Stroke Cerebrovasc Dis*. 2016;25(3):504-510. https://doi.org/10.1016/j.jstrokecerebrovasdis.2015.10.026. PMID:26617327.