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Title

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Permalink

<https://escholarship.org/uc/item/5kn6b82h>

Journal

Western Journal of Emergency Medicine: Integrating Emergency Care with Population Health, 20(2)

ISSN

1936-900X

Authors

Trent, Stacy A.
Morse, Erica A.
Ginde, Adit A.
[et al.](#)

Publication Date

2019

DOI

10.5811/westjem.2018.10.38731

Supplemental Material

<https://escholarship.org/uc/item/5kn6b82h#supplemental>

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Barriers to Prompt Presentation to Emergency Departments in Colorado after Onset of Stroke Symptoms

Stacy A. Trent, MD, MPH^{*†}

Erica A. Morse, MD[‡]

Adit A. Ginde, MD, MPH^{†§}

Edward P. Havranek, MD^{||}

Jason S. Haukoos, MD, MSc^{*†§}

^{*}Denver Health Medical Center, Department of Emergency Medicine, Denver, Colorado

[†]University of Colorado School of Medicine, Department of Emergency Medicine, Aurora, Colorado

[‡]St. Joseph's Hospital, Department of Emergency Medicine, Denver, Colorado

[§]Colorado School of Public Health, Department of Epidemiology, Aurora, Colorado

[¶]Denver Health Medical Center, Department of Medicine, Denver, Colorado

^{||}University of Colorado School of Medicine, Division of Cardiology, Aurora, Colorado

Section Editor: Edward P. Sloan, MD, MPH

Submission history: Submitted May 21, 2018; Revision received August 1, 2018; Accepted October 10, 2018

Electronically published December 5, 2018

Full text available through open access at http://escholarship.org/uc/uciem_westjem

DOI: 10.5811/westjem.2018.10.38731

Introduction: Despite significant morbidity and mortality from stroke, patient delays to emergency department (ED) presentation following the onset of stroke symptoms are one of the main contraindications to treatment for acute ischemic stroke (AIS). Our objective was to identify patient and environmental factors associated with delayed presentations to the ED after onset of stroke symptoms.

Methods: This was a pre-planned secondary analysis of data from a multicenter, retrospective observational study at three hospitals in Colorado. We included consecutive adult patients if they were admitted to the hospital from the ED, and the ED diagnosed or initiated treatment for AIS. Patients were excluded if they were transferred from another hospital. Primary outcome was delayed presentation to the ED (> 3.5 hours) following onset stroke symptoms.

Results: Among 351 patients, 63% presented to the ED more than 3.5 hours after onset of stroke symptoms. Adjusted results show that patients who presented in the evening hours (odds ratio [OR] [0.45], 95% confidence interval [CI] [0.3-0.8]), as compared to daytime, were significantly less likely to have a delayed presentation. Speaking a language other than English (Spanish [OR 3.3, 95% CI 1.2-8.9] and "other" [OR 9.1, 95% CI 1.2-71.0]), having known cerebrovascular risk factors (>2 risk factors [OR 2.4, 95% CI 1.05-5.4] and 1-2 risk factors [OR 2.3, 95% CI 1.03-5.1], compared to zero risk factors), and presenting to a rural hospital (OR 2.2, 95% CI 1.2-4.2), compared to urban, were significantly associated with delayed presentation.

Conclusion: Important patient and environmental factors are significantly associated with delayed ED presentations following the onset of stroke symptoms. Identifying how best to educate patients on stroke risk and recognition remains critically important. [West J Emerg Med. 2019;20(2)237-243.]

INTRODUCTION

Cerebrovascular disease is the fourth leading cause of death in the United States (U.S.).¹ For patients who survive a stroke, daily functionality may be permanently affected resulting in severe disability.² Intravenous thrombolysis

using tissue plasminogen activator (tPA) has the potential to improve morbidity in patients who present to an emergency department (ED) shortly after the onset of symptoms.³ Despite significant morbidity and mortality from stroke, patient delays to ED presentation following the onset of stroke symptoms

continue to be the main contraindication to using tPA for acute ischemic stroke (AIS).⁴ Our prior work examining variation in adherence to guideline recommendations for administration of tPA for AIS identified that most patients were not eligible for tPA because they presented to the ED well outside the recommended treatment window. Thus, our objective was to identify patient and environmental factors that may contribute to delays in presentation following the onset of stroke symptoms in our patient population.

METHODS

Study Design

We conducted a pre-planned, secondary analysis of data from a multicenter, retrospective observational study evaluating variation in ED adherence to cardiovascular and cerebrovascular guidelines, including systemic thrombolysis for AIS.⁵ The institutional review boards at each participating hospital approved the study with a waiver of consent.

Setting

This study was performed at three acute care hospitals in Colorado, including an urban safety-net hospital, a suburban, academic tertiary-care hospital, and a rural community hospital. All three EDs were staffed by board-certified/eligible emergency physicians. Annual adult ED census ranged from 55,000 to 80,000 patients at each hospital. Only the academic tertiary-care hospital was a certified Joint Commission Stroke Center. The rural community ED had neurologists available for consultation only by video, whereas the two other EDs had 24/7 in-house neurology consultation.

Population and Assembly of the Study Cohort

Consecutive patients were identified retrospectively by any hospital-discharge implantable cardioverter-defibrillator ICD-9 code for acute ischemic stroke (434.xx).⁶ Investigators at each site obtained a list of consecutive patients with the above ICD-9 codes, who were admitted from the ED beginning on December 31, 2012. From this initial cohort, each unique patient encounter was screened by a physician abstractor for inclusion using the following criteria: 1) a discharge diagnosis in the medical record of acute ischemic stroke; 2) admission to the hospital from the ED; and 3) diagnosis or initiated treatment for AIS in the ED. Exclusion criteria were age <18 years and patients transferred from another facility. Patient encounters were screened until we obtained a sufficient sample (n=117) at each institution.

Data Collection

Once the study cohort was established, structured medical record abstraction was performed using established, standard methodology.^{7,8} Using a structured data abstraction form, abstractors documented the presence of pre-specified variables necessary to assess guideline adherence for

Population Health Research Capsule

What do we already know about this issue?
Patient delays in presentation to an emergency department (ED) are one of the main contraindications to treatment for acute ischemic strokes.

What was the research question?
Our objective was to identify patient and environmental factors associated with delayed presentations to the ED.

What was the major finding of the study?
Time of day, patient language, cerebrovascular risk factors, and location of hospital were all significantly associated with delays in presentation.

How does this improve population health?
Identifying barriers to prompt presentation to an ED following the onset of stroke symptoms is the first step in identifying how to best educate patients on stroke risk and recognition.

tPA use in AIS, including time of symptom onset defined as last known normal (Appendix). In addition, patient sociodemographics, cerebrovascular comorbidities, stroke symptoms, arrival day and time were collected.⁹⁻¹² We stratified patients' stroke risk into one of three groups depending on the cumulative number of stroke comorbidities: none, 1-2, and > 2. Patient chief complaints were stratified into three groups related to how typical the complaint was for stroke: typical for stroke (focal weakness, numbness, or alteration in speech); associated with stroke (headache, ataxia, dizziness, fall, seizure, vision change, altered mental status); and other.

Outcomes

Our primary outcome was whether a patient arrived in the ED within the "presentation window" for tPA for AIS. Guidelines for the use of tPA in AIS require that it be initiated within 4.5 hours of symptom onset.^{3,4} The American Heart Association/American Stroke Association (AHA/ASA) guidelines further recommend that tPA be initiated within 60 minutes of arrival to the ED.⁴ Thus, patients who arrived within 3.5 hours of symptom onset were defined as having

arrived within the “presentation window” in which tPA could be expected to be initiated within 4.5 hours of symptom onset.

Data Management and Statistical Analyses

We performed all data management and statistical analysis using Statistical Analysis System (SAS) (SAS Institute, Inc., Cary, NC). Descriptive statistics were calculated for all variables. We reported continuous data as medians with interquartile ranges (IQR) and categorical variables as percentages with 95% confidence intervals (CI). A p -value < 0.05 was considered statistically significant. We assessed inter-rater reliability on the outcome variable using Cohen’s kappa. A random sample of 15% of cases were re-abstracted with near-perfect agreement ($\kappa = 0.96$).

We used unadjusted logistic regression to estimate the association of each patient and environmental variable with patient presentation to the ED within the treatment window. Hierarchical multivariable logistic regression

was used to estimate associations between patient and environmental factors and presentation to the ED within the treatment window. We assessed effect modification between gender and chief complaint as well as language and chief complaint. Significant collinearity was identified between race and insurance as well as language and insurance; thus, we removed insurance from the final multivariable model.

Sample Size Estimation

The parent study was powered to estimate adherence variation from an a priori-defined 95% adherence threshold.⁵ The parent study included 117 patients with AIS from each hospital, for a total 351 patients.

RESULTS

Table 1 describes the sociodemographics, cerebrovascular comorbidities, and presenting characteristics of the 351 patients. The median time from symptom onset to presentation

Table 1. Characteristics of patients presenting with stroke symptoms.

	Combined cohort		Inside presentation window		Outside presentation window*	
	%	(n)	%	(95% CI)	%	(95% CI)
Cohort	100	(351)	36.8	(32-42)	63.2	(58-68)
Time since normal (median minutes, IQR)	420.0	(90-1020)	60.0	(30-120)	840.0	(480-2160)
Sociodemographics						
Age (median, IQR)	66.0	(57-78)	69.0	(57-80)	65.0	(57-77)
Gender						
Male	49.3	(173)	50.4	(42-59)	48.6	(42-55)
Female	50.7	(178)	49.6	(41-58)	51.4	(45-58)
Race/ethnicity						
Non-Hispanic White	54.4	(191)	52.7	(44-61)	55.4	(49-62)
Hispanic	25.9	(91)	28.7	(22-37)	24.3	(19-30)
Non-Hispanic Black	16.0	(56)	14.7	(10-22)	16.7	(12-22)
Other	3.7	(13)	3.9	(2-9)	3.7	(2-7)
Language						
English	86.9	(305)	90.7	(84-95)	84.7	(79-89)
Spanish	9.1	(32)	7.0	(4-13)	10.4	(7-15)
Other	4.0	(14)	2.3	(1-7)	5.0	(3-9)
Primary insurance						
Medicare	52.1	(183)	56.6	(48-65)	49.6	(43-56)
Medicaid	8.6	(30)	5.4	(3-11)	10.4	(7-15)
Commercial	16.0	(56)	17.8	(12-25)	14.9	(11-20)
Other source	16.8	(59)	16.3	(11-24)	17.1	(13-23)
Uninsured	6.6	(23)	3.9	(2-10)	8.1	(5-14)

CI, confidence interval; IQR, interquartile range.

*Presentation window defined as presenting in ≤ 210 minutes from onset of symptoms.

Table 1. Continued.

	Combined cohort		Inside presentation window		Outside presentation window*	
	%	(n)	%	(95% CI)	%	(95% CI)
Patient risk and complaint						
Comorbidities						
Atrial fibrillation	12.8	(45)	13.2	(8-20)	12.6	(9-18)
Cerebrovascular disease	26.5	(93)	24.0	(13-26)	27.9	(22-34)
Congestive heart failure	5.4	(19)	7.0	(3-11)	4.5	(2-8)
Coronary artery disease	18.5	(65)	21.7	(15-30)	16.7	(12-22)
Diabetes	30.5	(107)	27.1	(15-29)	32.4	(27-39)
Hypercholesterolemia	36.8	(129)	33.3	(26-42)	38.7	(33-45)
Hypertension	72.1	(253)	71.3	(63-78)	72.5	(66-78)
Tobacco use	31.9	(112)	28.7	(22-37)	33.8	(28-40)
Chief complaint						
Typical for stroke	68.4	(240)	68.2	(60-76)	68.5	(62-74)
Associated with stroke	27.4	(96)	26.4	(20-35)	27.9	(22-34)
Other	4.3	(15)	5.4	(3-11)	3.6	(2-7)
Environmental variables						
Time of presentation						
Day (7 AM -4:59 PM)	64.1	(225)	55.0	(46-63)	69.4	(63-75)
Evening (5 PM-11:59 PM)	27.6	(97)	36.4	(29-45)	22.5	(18-28)
Night (midnight-6:59 AM)	8.3	(29)	8.5	(5-15)	8.1	(5-12)
Day of week						
Weekday (Mon 7 AM-Fri 4:59 PM)	63.0	(221)	59.7	(51-68)	64.9	(58-71)
Weekend (Fri 5 PM-Mon 6:59 AM)	37.0	(130)	40.3	(32-49)	35.1	(29-42)
Hospital location						
Rural	33.3	(117)	37.2	(29-46)	31.1	(25-37)
Suburban	33.3	(117)	39.5	(32-48)	29.7	(24-36)
Urban	33.3	(117)	23.3	(17-31)	39.2	(33-46)

CI, confidence interval; IQR, interquartile ratio.

*Presentation window defined as presenting in ≤ 210 minutes from onset of symptoms.

to the ED was 420 minutes (IQR [90-1020]) (i.e., seven hours). Only 37% of patients presented to the ED within the treatment window. For patients arriving within the treatment window, the median time from symptom onset was 60 minutes (IQR [30-120]) as compared to 840 minutes (IQR [480-2160]) for patients who arrived outside the treatment window.

Table 2 describes both the unadjusted and adjusted associations between patient and environmental variables and delayed presentations to the ED after the onset of stroke symptoms. Adjusted results show that patients who presented in the evening hours were significantly less likely to have a delayed presentation as compared to patients who presented during daytime hours (odds ratio [OR] {0.45}, 95% CI [0.3-

0.8]). Speaking a language other than English (Spanish [OR {3.3}, 95% CI {1.2-8.9}] and "other" [OR {9.1}, 95% CI {1.2-71.0}]), having known cerebrovascular risk factors (>two risk factors [OR 2.4, 95% CI {1.05-5.4}] and one to two risk factors [OR {2.3}, 95% CI {1.03-5.1}]), and presenting to a rural hospital (OR [2.2], 95% CI [1.2-4.2]) were significantly associated with delayed presentation.

DISCUSSION

Despite the significant effect of stroke on morbidity and mortality in the U.S., much of the literature for AIS focuses on the importance of minimizing treatment delays in patients who present to the ED within the tPA treatment window.¹³⁻¹⁹

Table 2. Bivariate and multivariate associations for late presentation (> 3.5 hours) to emergency department after onset of stroke symptoms.

	Unadjusted		Multivariable model	
	OR	(95% CI)	OR	(95% CI)
Sociodemographics				
Age	0.99	(0.98-1.01)	0.98	(0.97-1.00)
Gender				
Male	Ref		Ref	
Female	1.07	(0.70-1.65)	1.06	(0.66-1.70)
Race/Ethnicity				
Non-Hispanic White	Ref		Ref	
Hispanic	0.75	(0.45-1.26)	0.58	(0.30-1.11)
Non-Hispanic Black	0.99	(0.54-1.85)	1.16	(0.57-2.34)
Other	0.95	(0.30-3.24)	0.31	(0.05-1.94)
Language				
English	Ref		Ref	
Spanish	1.51	(0.71-3.43)	3.25	(1.20-8.88)
Other	2.51	(0.77-11.3)	9.13	(1.17-71.0)
Primary insurance*				
Medicare	Ref			
Medicaid	2.33	(1.00-6.13)		
Commercial	0.82	(0.45-1.50)		
Other source	1.20	(0.66-2.21)		
Uninsured	2.01	(0.80-5.79)		
Patient risk and complaint				
Number of stroke comorbidities				
None	Ref		Ref	
1-2	1.92	(0.90-4.09)	2.3	(1.03-5.14)
> 2	2.00	(0.93-4.32)	2.4	(1.05-5.44)
Chief complaint				
Typical for stroke	Ref		Ref	
Associated with stroke	1.01	(0.62-1.65)	1.05	(0.61-1.79)
Other	0.72	(0.25-2.13)	0.67	(0.22-2.07)
Environmental variables				
Time of presentation				
Day (7 AM-4:59 PM)	Ref		Ref	
Evening (5 PM-11:59 PM)	0.54	(0.33-0.88)	0.46	(0.27-0.77)
Night (midnight-6:59 AM)	0.87	(0.40-1.98)	0.66	(0.28-1.57)
Day of week				
Weekday (Mon 7 AM-Fri 4:59 PM)	Ref		Ref	
Weekend (Fri 5 PM-Mon 6:59 AM)	0.85	(0.54-1.32)	0.88	(0.54-1.44)
Hospital location				
Urban	Ref		Ref	
Rural	1.76	(1.03-3.04)	2.23	(1.18-4.20)
Suburban	0.84	(0.50-1.41)	0.76	(0.42-1.39)

OR, odds ratio; CI, confidence interval; Ref, reference value.

*Multicollinearity between race and insurance, and language and insurance.

As acknowledged in a statement from the AHA, the weak link in applying stroke treatments is patient delay in seeking care.²⁰ Unfortunately, our results mirror those reported in the literature over the past 30 years, which show that the vast majority of patients are excluded from treatment due to delays in presentation.²⁰⁻²⁸

We identified four possible barriers to prompt presentation to an ED in our cohort: primary language, stroke risk, time of day of ED presentation, and hospital location. Speaking a primary language other than English was significantly associated with delays in presentation to the ED. Two possible explanations for our finding include differences in knowledge and recognition of stroke symptoms, and reluctance to use emergency medical services (EMS) given a language barrier.^{29,30} We expected patients with known stroke-risk factors to present to the ED promptly. However, we found the opposite, which contrasts with Lacy who showed no association.³¹ Given that we treated all risk factors equally in our analysis, it is possible that patients with less-obvious stroke comorbidities were unaware of their personal risk for stroke.^{32,33}

The association of time of day and timing of ED presentation is likely explained by the effect of nocturnal onset of symptoms. Patients presenting in the morning after awakening with symptoms are almost always outside the treatment window as their last known normal time was their bedtime.^{34,35} While not specifically abstracted, we estimate that 12% of our cohort had “wake-up” strokes. Moreover, patients who presented in the evening hours were likely to have developed symptoms when family or co-workers were present to notice the symptoms. Lastly, it is not surprising that patients who present to a more rural hospital would have delays in presentation. While we do not have information on each patient regarding their exact distance traveled to each hospital in the study, it is reasonable to expect that patients presenting to more rural hospitals would have longer transport times than patients presenting to more urban hospitals.³⁶

LIMITATIONS

The primary limitation of this study was its use of secondary data. While these data captured the appropriate population to address our study objective, important confounders were not measured, namely EMS use and stroke severity, both of which have been shown to be associated with timing of arrival to the ED.^{25-27,37}

CONCLUSION

Important patient and environmental factors are significantly associated with delayed ED presentations following the onset of stroke symptoms. Identifying how best to educate patients on stroke risk and recognition remains critically important.

Address for Correspondence: Stacy Trent, MD, MPH, Denver Health Medical Center, Department of Emergency Medicine, 777 Bannock St, Mail Code 0108, Denver, CO 80204. Email: Stacy.trent@dhha.org.

Conflicts of Interest: By the WestJEM article submission agreement, all authors are required to disclose all affiliations, funding sources and financial or management relationships that could be perceived as potential sources of bias. No author has professional or financial relationships with any companies that are relevant to this study. There are no conflicts of interest or sources of funding to declare.

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REFERENCES

1. Statistics National Center for Health Statistics. Health, United States, 2016: With Chartbook on Long-term Trends in Health. Hyattsville, MD. *Health, United States*. 2017.
2. Prevalence and most common causes of disability among adults--United States, 2005. *MMWR Morb Mortal Wkly Rep*. 2009;58(16):421-6.
3. Wardlaw JM, Murray V, Berge E, et al. Thrombolysis for acute ischaemic stroke. *Cochrane Database Syst Rev*. 2014(7):CD000213.
4. Powers WJ, Rabinstein AA, Ackerson T, et al. 2018 Guidelines for the Early Management of Patients with Acute Ischemic Stroke: A Guideline for Healthcare Professionals from the American Heart Association/American Stroke Association. *Stroke*. 2018;49(3):e46-e110.
5. Trent SA, Johnson MA, Morse EA, et al. Patient, provider, and environmental factors associated with adherence to cardiovascular and cerebrovascular clinical practice guidelines in the ED. *Am J Emerg Med*. 2018;36(8):1397-404.
6. McCormick N, Bhole V, Lacaille D, et al. Validity of diagnostic codes for acute stroke in administrative databases: a systematic review. *PLoS One*. 2015;10(8):e0135834.
7. Kaji AH, Schriger D, Green S. Looking through the retrospectroscope: reducing bias in emergency medicine chart review studies. *Ann Emerg Med*. 2014;64(3):292-8.
8. Gilbert EH, Lowenstein SR, Koziol-McLain J, et al. Chart reviews in emergency medicine research: Where are the methods? *Ann Emerg Med*. 1996;27(3):305-8.
9. Pham JC, Kelen GD, Pronovost PJ. National study on the quality of emergency department care in the treatment of acute myocardial infarction and pneumonia. *Acad Emerg Med*. 2007;14(10):856-63.
10. Mikkelsen ME, Gaieski DF, Goyal M, et al. Factors associated with nonadherence to early goal-directed therapy in the ED. *Chest*. 2010;138(3):551-8.

11. Halm EA, Atlas SJ, Borowsky LH, et al. Understanding physician adherence with a pneumonia practice guideline: effects of patient, system, and physician factors. *Arch Intern Med*. 2000;160(1):98-104.
12. Meurer WJ, Majersik JJ, Frederiksen SM, et al. Provider perceptions of barriers to the emergency use of tPA for acute ischemic stroke: a qualitative study. *BMC Emerg Med*. 2011;11:5.
13. Fonarow GC, Smith EE, Saver JL, et al. Timeliness of tissue-type plasminogen activator therapy in acute ischemic stroke: patient characteristics, hospital factors, and outcomes associated with door-to-needle times within 60 minutes. *Circulation*. 2011;123(7):750-8.
14. Sauser K, Levine DA, Nickles AV, et al. Hospital variation in thrombolysis times among patients with acute ischemic stroke: the contributions of door-to-imaging time and imaging-to-needle time. *JAMA Neurol*. 2014;71(9):1155-61.
15. Schwamm LH, Ali SF, Reeves MJ, et al. Temporal trends in patient characteristics and treatment with intravenous thrombolysis among acute ischemic stroke patients at Get with the Guidelines-Stroke hospitals. *Circ Cardiovasc Qual Outcomes*. 2013;6(5):543-9.
16. Saver JL, Fonarow GC, Smith EE, et al. Time to treatment with intravenous tissue plasminogen activator and outcome from acute ischemic stroke. *JAMA*. 2013;309(23):2480-8.
17. Skolarus LE, Meurer WJ, Shanmugasundaram K, et al. Marked regional variation in acute stroke treatment among Medicare beneficiaries. *Stroke*. 2015;46(7):1890-6.
18. Madej-Fermo OP, Staff I, Fortunato G, et al. Impact of emergency department transitions of care on thrombolytic use in acute ischemic stroke. *Stroke*. 2012;43(4):1067-74.
19. 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):e255-61.
20. Moser DK, Kimble LP, Alberts MJ, et al. Reducing delay in seeking treatment by patients with acute coronary syndrome and stroke: a scientific statement from the American Heart Association Council on cardiovascular nursing and stroke council. *Circulation*. 2006;114(2):168-82.
21. Hacke W, Donnan G, Fieschi C, et al. Association of outcome with early stroke treatment: pooled analysis of ATLANTIS, ECASS, and NINDS rt-PA stroke trials. *Lancet*. 2004;363(9411):768-74.
22. Kwiatkowski T, Libman R, Tilley BC, et al. The impact of imbalances in baseline stroke severity on outcome in the National Institute of Neurological Disorders and Stroke Recombinant Tissue Plasminogen Activator Stroke Study. *Ann Emerg Med*. 2005;45(4):377-84.
23. 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):1806-12.
24. Doggen CJ, Zwerink M, Droste HM, et al. Prehospital paths and hospital arrival time of patients with acute coronary syndrome or stroke, a prospective observational study. *BMC Emerg Med*. 2016;16:3.
25. Ekundayo OJ, Saver JL, Fonarow GC, et al. Patterns of emergency medical services use and its association with timely stroke treatment: findings from Get With the Guidelines-Stroke. *Circ Cardiovasc Qual Outcomes*. 2013;6(3):262-9.
26. 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.
27. Turan TN, Hertzberg V, Weiss P, et al. Clinical characteristics of patients with early hospital arrival after stroke symptom onset. *J Stroke Cerebrovasc Dis*. 2005;14(6):272-7.
28. Evenson KR, Rosamond WD, Morris DL. Prehospital and in-hospital delays in acute stroke care. *Neuroepidemiology*. 2001;20(2):65-76.
29. DuBard CA, Garrett J, Gizlice Z. Effect of language on heart attack and stroke awareness among U.S. Hispanics. *Am J Prev Med*. 2006;30(3):189-96.
30. Smith MA, Lisabeth LD, Bonikowski F, et al. The role of ethnicity, sex, and language on delay to hospital arrival for acute ischemic stroke. *Stroke*. 2010;41(5):905-9.
31. Lacy CR, Suh DC, Bueno M, et al. 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):63-9.
32. Hickey A, O'Hanlon A, McGee H, et al. Stroke awareness in the general population: knowledge of stroke risk factors and warning signs in older adults. *BMC Geriatr*. 2009;9:35.
33. Kleindorfer D, Khoury J, Broderick JP, et al. Temporal trends in public awareness of stroke: warning signs, risk factors, and treatment. *Stroke*. 2009;40(7):2502-6.
34. Williams LS, Bruno A, Rouch D, et al. Stroke patients' knowledge of stroke. Influence on time to presentation. *Stroke*. 1997;28(5):912-5.
35. Wester P, Radberg J, Lundgren B, et al. Factors associated with delayed admission to hospital and in-hospital delays in acute stroke and TIA: a prospective, multicenter study. Seek- Medical-Attention-in-Time Study Group. *Stroke*. 1999;30(1):40-8.
36. Nedeltchev K, Arnold M, Brekenfeld C, et al. Pre- and in-hospital delays from stroke onset to intra-arterial thrombolysis. *Stroke*. 2003;34(5):1230-4.
37. Centers for Disease Control and Prevention (CDC). Prehospital and hospital delays after stroke onset--United States, 2005-2006. *MMWR Morb Mortal Wkly Rep*. 2007;56(19):474-8.