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Emergency Medical Services Utilization for Acute Stroke Care: Analysis of the Paul Coverdell National Acute Stroke Program, 2014–2019

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Abstract

Objective: Emergency medical service (EMS) transportation after acute stroke is associated with shorter symptom-to-arrival times and more rapid medical attention when compared to patient transportation by private vehicle.

Methods: We analyzed data from the Paul Coverdell National Acute Stroke Program from 2014 to 2019 among stroke (ischemic and hemorrhagic) and transient ischemic attack (TIA) patients to examine patterns in EMS utilization.

Results: Of 500,829 stroke and TIA patients (mean age 70.9 years, 51.3% women) from 682 participating hospitals during the study period, 60% arrived by EMS. Patients aged 18–64 years vs. ≥65 years (AOR 0.67) were less likely to utilize EMS. Severe stroke patients (AOR 2.29, 95%CI, 2.15–2.44) and hemorrhagic stroke patients vs. ischemic stroke patients (AOR 1.47, 95% CI, 1.43–1.51) were more likely to utilize EMS. Medicare (AOR 1.35, 95% CI, 1.32–1.38) and Medicaid (AOR 1.41, 95% CI, 1.37–1.45) beneficiaries were more likely than privately insured

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patients to utilize EMS, but no difference was found between no insurance/self-pay patients and privately insured patients on EMS utilization. Overall, there was a decreasing trend in the utilization of EMS (59.6% to 59.3%, p=0.037). The decreasing trend was identified among ischemic stroke (p<0.0001) patients but not among TIA (p=0.89) or hemorrhagic stroke (p=0.44) patients. There was no observed trend in pre-notification among stroke patients' arrival by EMS across the study period (56.9% to 56.5%, p=0.99).

Conclusions: Strategies to help increase stroke awareness and utilization of EMS among those with symptoms of stroke should be considered in order to help improve stroke outcomes.

Keywords

emergency medical services; ischemic stroke; prehospital

BACKGROUND

Stroke remains a major cause of death and severe disability and results in over $45 billion each year in direct and indirect medicals costs within the United States.[1–3] Stroke prevalence is approximately 3%, or about 7 million people in the United States, and is expected to increase in the future and resulted in 147,810 stroke deaths (5.2% of all deaths) in 2018.[1] Timely medical attention for stroke patients is critical. Patients who utilize emergency medical services (EMS) can arrive to the hospital more rapidly when compared to those who seek medical attention via other means of transportation.[4] Use of EMS can lead to quicker time to evaluation in the emergency department, involvement of a neurologist, and time to cranial imaging, and can increase the likelihood of intravenous thrombolysis (IVT) among eligible stroke patients.[4] It has been estimated that if all stroke patients in the United States with known onset time utilized EMS, hospitals could achieve up to 29% IVT treatment rates.[5] For hemorrhagic strokes, timely blood pressure adjustment and normalization of coagulation status has been shown to improve outcomes.[3] Estimates of EMS utilization have been varied, ranging from 38 to 65%.[5] In this study we used a multi-state stroke registry in the United States to examine the recent EMS utilization practices over six years.

METHODS

There were a total of 685,060 patients with clinical diagnoses of stroke (ischemic and hemorrhagic) or transient ischemic attack (TIA), including transferred patients within the Paul Coverdell National Acute Stroke Program (PCNASP) presenting to 720 hospitals participating from January 1, 2014, to December 31, 2019. Of these patients, there were 500,829 patients with stroke and TIA directly admitted with arrival mode (EMS from home or scene versus private transportation/taxi/other) and insurance information available. Patients studied were those who were directly admitted to participating hospitals and not those admitted in transfer from another facility. The PCNASP is supported by the Centers for Disease Control and Prevention (CDC) and is an ongoing acute stroke quality improvement program that provides feedback to states in order to improve quality of care for patients across the stroke care continuum. During the study period, there were 12 participating states (Arkansas, California, Georgia, Iowa, Massachusetts, Michigan, Minnesota, New York, North Carolina, Ohio, Washington, and Wisconsin). Hospital

participation within each state is voluntary. Trained abstractors collect detailed information on stroke and TIA admissions concurrent with or soon after hospital discharge using standard data definitions provided by the CDC.[6,7] The study was approved by the CDC Institutional Review Board.

Demographic information collected for each admission included: age, sex, race/ethnicity, and insurance status. Baseline clinical characteristics included stroke severity upon presentation as defined by the National Institutes of Health Stroke Scale (NIHSS) score, pre-notification among those arrived by EMS, ambulatory status, history of prior stroke, hypertension, dyslipidemia, coronary artery disease, heart failure, diabetes mellitus, atrial fibrillation, and current tobacco use.

We performed both univariate and multivariate logistic regression analyses using generalized estimating equations (GEE) to assess factors associated with EMS utilization for acute stroke care. Because patients were clustered within hospitals, the hospital was treated as a cluster variable in GEE models. We also analyzed the effect of EMS utilization on door-to-needle time (DNT) metrics among ischemic stroke patients treated with IVT ≤4.5 hours of symptom onset. We then examined trends in the utilization of EMS and pre-hospital notification of stroke patients across the study period by year and obtained p-values based on the Cochran-Armitage trend test. Descriptive data are presented as counts with frequencies (percentages), median values with inter-quartile ranges (IQR), or mean values with standard error (SE), as appropriate. All statistical analyses were performed using SAS software (version 9.4; SAS Institute, Cary, NC).

RESULTS

Among included patients, the mean age was 70.9 years and 51.3% were women. Approximately 59.8% of patients arrived by EMS and 40.2% by private transportation/taxi/other (Table 1). Patients arriving by EMS were older (73.1 years versus 67.6 years) and more frequently women (53.2% versus 48.6%) when compared to those arriving by private vehicle. Patients arriving by EMS had higher median NIHSS scores than those arriving by private vehicle (5 [2, 12] versus 2 [0, 3]). Fewer patients arriving at the hospital via EMS had private insurance than those arriving by private vehicle (19.2% versus 28.9%); however, a higher percentage of those arriving by EMS had Medicare as opposed to private vehicle (69.4% versus 57.7%). A higher percentage of patients with hemorrhagic strokes arrived by EMS as opposed to private vehicle (14% versus 6.8%), but TIA patients arrived by EMS less frequently than by private vehicle (12.1% versus 17.1%). The percent of ischemic stroke patients using EMS or private vehicle was similar (73.9% versus 76.1%) (Table 1).

Among patients with ischemic stroke treated with IVT ≤4.5 hours of symptom onset, the median DNT was shorter among patients arriving by EMS compared to those arriving by private vehicle (49 [36, 68] minutes versus 58 [44, 79] minutes). A higher proportion of ischemic stroke patients arriving by EMS experienced DNTs ≤60 minutes (67.8% versus 54.5%), ≤45 minutes (43.0% versus 27.1%), and ≤30 minutes (14.9% versus 6.1%) when compared to those arriving by private vehicle (Table 2). Adjusted odds ratios showed that patients arriving by EMS as compared to private vehicle were more likely to be treated with

IVT within 60 minutes, 45 minutes, or 30 minutes of ED arrival (AOR 1.61 [CI 1.53–1.69], 1.88 [CI 1.78–1.98], and 2.53 [CI 2.31–2.78], respectively) (Table 3).

Factors associated with EMS utilization for acute stroke care are found in Table 4. Patients aged 18–64 years were less likely to utilize EMS as a compared to patients aged ≥65 (AOR 0.67 [95% CI 0.66–0.68]). Hispanic patients (AOR 0.76 [95% CI 0.74–0.79]) or patients of other race/ethnicities (AOR 0.85 [95% CI 0.83–0.88]) were less likely to utilize EMS as compared to non-Hispanic White patients. Patients with NIHSS scores ≤10 were less likely (AOR 0.38 [95% CI 0.134–0.142]) and those with NIHSS scores >20 were more likely (AOR 2.29 [95% CI 2.15–2.44]) to utilize EMS as compared to those with NIHSS scores between 11–20. Patients with hemorrhagic stroke were more likely (AOR 1.47 [95% CI 1.43–1.51]) and patients with TIA were less likely (AOR 0.91 [95% CI 0.89–0.92]) to utilize EMS as compared ischemic stroke patients. Both Medicare (AOR 1.35 [95% CI 1.32–1.38]) and Medicaid (AOR 1.41 [95% CI 1.37–1.45]) beneficiaries were more likely than privately insured patients to utilize EMS, but no difference was found between patients with no insurance (self-pay) and privately insured patients on EMS utilization (AOR 1.02 [95% CI 0.98–1.05]).

From 2014 to 2019, we identified a decreasing trend in the utilization of EMS overall (59.6% to 59.3%, p=0.037) and among patients with ischemic stroke (59.3% to 58.1%, p<0.0001) (Table 5). The trends for EMS utilization among patients with TIA (p=0.89) or hemorrhagic stroke (p=0.44) did not change. There was no observed trend across the study period in pre-notification (56.9% to 56.5%, p=0.99) by EMS to participating hospitals (Figure).

DISCUSSION

The utilization of EMS has been shown to decrease pre-hospital delays among patients with acute stroke in several studies.[3–5,8] We found that older patients, patients with hemorrhagic stroke, and patients with more severe strokes were more likely to utilize EMS, which aligns with previous findings.[4,5] Contrary to Odeoye and colleagues who found no difference in EMS utilization between patients with ischemic stroke or TIA,[5] we found that patients with TIA were less likely than patients with ischemic stroke to utilize EMS in our study period. However, a higher percentage of patients with TIA in our study utilized EMS as compared to what was found previously by Kleindorfer and colleagues in 2006,[8] which is likely related to improvement in public knowledge of stroke signs and symptoms.[9]

There was no significant trend in EMS utilization among patients with hemorrhagic stroke across the study period. Overall hemorrhagic stroke patients were more likely to utilize EMS as compared to ischemic stroke patients. Hemorrhagic stroke patients require immediate attention in the emergency department. Hematoma expansion can occur within six hours after symptom onset, and the rates of hematoma expansion are higher among patients on systemic anticoagulation.[10] Faster normalization of coagulation status is associated with less hematoma expansion and improved outcomes.[3] Achieving early and stable blood pressures are also associated with favorable outcomes.[11]

After adjustment, Hispanic patients were less likely than non-Hispanic White patients to utilize EMS, which is consistent with previous studies.[12,13] Lower EMS utilization could be due to English proficiency and health literacy.[13] Hispanic patients have been reported to present without motor or speech deficits, and better recognized stroke symptoms, which may have led to lower utilization rates as well.[13]

Medicare and Medicaid beneficiaries were more likely than privately insured patients to arrive by EMS. There was no difference between privately insured patients and patients without insurance or those who self-pay. It has been reported in the past that there was no association between EMS usage and insurance status.[9] High rates of EMS arrival by Medicare beneficiaries is consistent with the strong likelihood of patients over the age of 65 years seeking ambulance care for medical emergencies.[14] Medicaid beneficiaries, who are low-income by definition, may seek EMS care as they may be less likely to have access to private transportation.[14] Predictors of EMS utilization among uninsured patients may require more investigation.

A higher proportion of patients with ischemic stroke using EMS experienced DNTs within 60-, 45-, and 30-minutes than those arriving by private vehicle in our study. We know that faster time to treatment would deliver the greatest benefit from reperfusion therapies among eligible patients with ischemic stroke.[3] Guidelines published by the American Heart Association/American Stroke Association recommend pre-notification where EMS notifies the target hospital that a patient with a potential stroke is en route, which is an evidence-based strategy to accelerate in-hospital stroke management.[15] However, we did not find any overall change in the pre-notification of patients utilizing EMS in our study. Pre-notification from paramedics to the emergency department and stroke team has been found to save up to 30 minutes upon hospital arrival resulting in faster bedside evaluation and imaging.[3] Approximately 89% of stroke patients will have face, arm, or speech affected,[3] but the capabilities for pre-hospital stroke recognition of less common stroke symptoms can be low.[16] The likely cause of low sensitivity for pre-hospital stroke recognition is explained by the minimal formal training of EMS personnel on neurological emergencies.[16] In conjunction with training programs for pre-hospital providers to increase stroke recognition, educational efforts may be directed to entire communities on stroke symptoms and signs.[16,17] Our observed decreased trend in EMS utilization, particularly among patients with ischemic stroke, needs further investigation to identify its public health and clinical implications. Efforts to improve EMS utilization as well as pre-notification will require educational endeavors to the public, EMS crews, hospital systems, and all participants within stroke teams.

Over the past decade, mobile stroke units (MSUs) have been developed to narrow the gap between stroke onset and intervention.[18] There are approximately 30 MSUs currently operating worldwide.[3] While showing promise, the safety and efficacy of current approaches to MSUs have not yet been shown in adequately powered studies.[19] Pre-hospital stroke treatment with MSUs could be demonstrated in various healthcare systems with differing configurations of emergency care, legislation requirements, and market forces in order to confirm generalizability.[2] Additionally, there is no active billing code provided by the Centers for Medicare and Medicaid Services to reimburse MSUs for the cost of IVT given

in the pre-hospital environment.[18] Future studies could provide data to support financial investment in MSUs.

This is the first publication of PCNASP data to describe prehospital stroke care. The PCNASP began collecting prehospital stroke care data in 2015 for quality improvement efforts and program awardees have worked to implement public education campaigns along with training among EMS groups (https://www.cdc.gov/dhdsp/programs/ems.htm). While awareness of stroke symptoms and the use of 911/EMS has increased among Americans, it remains suboptimal.[10]

Strengths of our study include the large number of patients, and the multi-state information from a variety of hospital stroke levels of certification collected during regular delivery of stroke care making our results generalizable. We acknowledge important limitations, including participation bias that may exist since participation in PCNASP is voluntary. Participating hospitals make every effort to abstract all stroke cases in order to minimize reporting bias.[20]

In conclusion, we found that among ischemic stroke patients utilizing EMS, DNTs were shorter than those who presented by private vehicle. Medicare and Medicaid beneficiaries were more likely to utilize EMS when compared to those privately insured, but there was no difference between privately insured patients and those without insurance in EMS utilization. Despite evidence-based guidelines there has not been an increase in hospital pre-notification of stroke patients utilizing EMS to participating hospitals. Further education and quality improvement endeavors should be considered.

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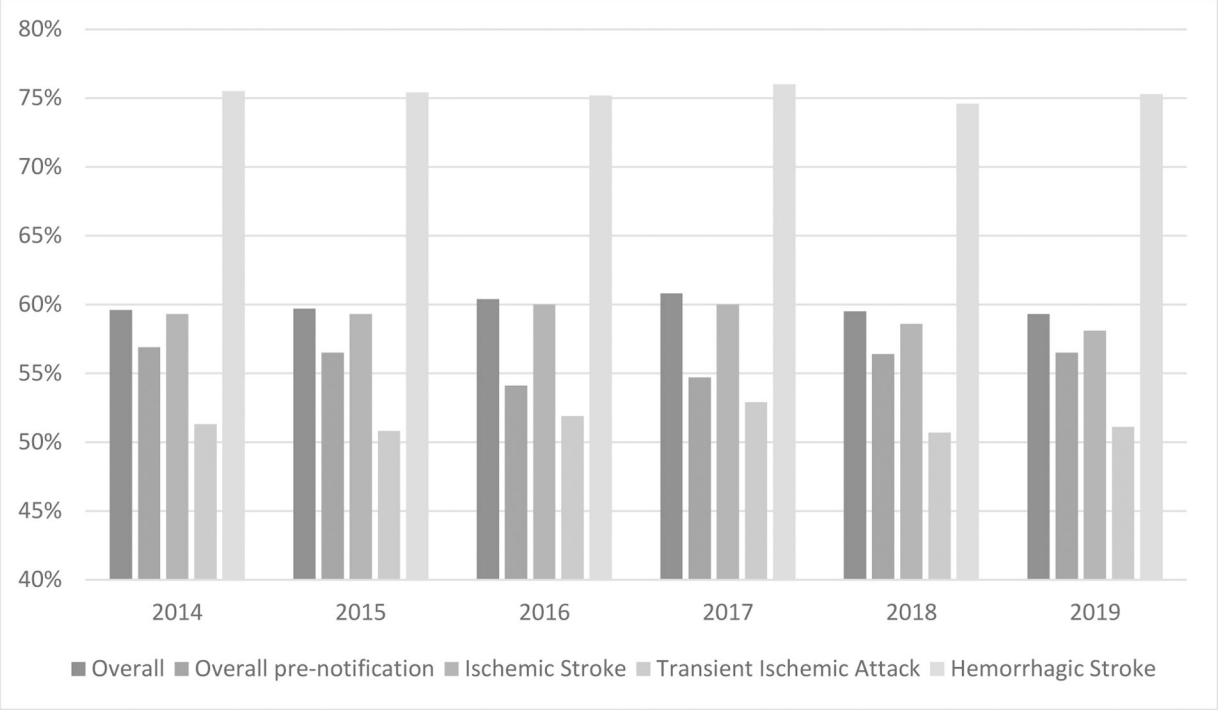

Figure:
Trends in Emergency Medical Services Utilization for Acute Stroke Care, 2014–2019

Table 1:

Baseline Characteristics of Patients Based on Arrival Mode to Participating Hospitals for Acute Stroke Care, 2014–2019

Variables	Overall n (%) (N=500829)	EMS (n=299590)	Private vehicle (n=201239)
Mean (SE) Age in years	70.9 (0.0)	73.1 (0.0)	67.6 (0.0)
Age in groups			
18–64	163725 (32.7)	82567 (27.6)	81158 (40.3)
≥65	337104 (67.3)	217023 (72.4)	120081 (59.7)
Women	256994 (51.3)	159255 (53.2)	97739 (48.6)
Race/ethnicity			
Non-Hispanic White	345450 (69.0)	208845 (69.7)	136605 (67.9)
Non-Hispanic Black	95767 (19.1)	57166 (19.1)	38601 (19.2)
Hispanic	22649 (4.5)	12044 (4.0)	10605 (5.3)
Other race	36963 (7.4)	21535 (7.2)	15428 (7.7)
Median NIHSS score [IQR]	3 [1, 7]	5 [2, 12]	2 [0, 3]
NIHSS score in groups			
Missing	60415 (12.1)	37831 (12.6)	22584 (11.2)
0–10	360985 (72.1)	188957 (63.1)	172028 (85.5)
11–20	50465 (10.1)	45155 (15.1)	5310 (2.6)
>20	28964 (5.8)	27647 (9.2)	1317 (0.7)
Co-morbidities			
Hypertension	381210 (76.1)	232077 (77.5)	149133 (74.1)
Hypercholesterolemia	245573 (49.0)	145117 (48.4)	100456 (49.9)
Diabetes	166712 (33.3)	98380 (32.8)	68332 (34.0)
Current smoker	85383 (17.0)	46456 (15.5)	38927 (19.3)
CAD/MI	113541 (22.7)	72138 (24.1)	41403 (20.6)
AF	92247 (18.4)	66527 (22.2)	25720 (12.8)
Heart failure	49567 (9.9)	35153 (11.7)	14414 (7.2)
Prior stroke	130920 (26.1)	83903 (28.0)	47017 (23.4)
Ambulatory status prior to stroke			
Missing	5994 (1.2)	3591 (1.2)	2403 (1.2)
Ambulates with or without assistive device	425181 (84.9)	241140 (80.5)	184041 (91.5)
Assistance from another person	25821 (5.2)	20147 (6.7)	5674 (2.8)
Unable to ambulate	15668 (3.1)	13772 (4.6)	1896 (0.9)
Not determined	28165 (5.6)	20940 (7.0)	7225 (3.6)
Insurance			
Medicaid	42919 (8.6)	24959 (8.3)	17960 (8.9)
Medicare	324079 (64.7)	207895 (69.4)	116184 (57.7)
Private	115646 (23.1)	57562 (19.2)	58084 (28.9)
Self-pay/no insurance	18185 (3.6)	9174 (3.1)	9011 (4.5)

Variables	Overall n (%) (N=500829)	EMS (n=299590)	Private vehicle (n=201239)
Clinical diagnosis			
Hemorrhagic	55717 (11.1)	41947 (14.0)	13770 (6.8)
Ischemic	374428 (74.8)	221293 (73.9)	153135 (76.1)
TIA	70684 (14.1)	36350 (12.1)	34334 (17.1)
In-hospital death	26305 (5.3)	24420 (8.2)	1885 (0.9)

Abbreviations: IQR=inter-quartile range; NIHSS=National Institutes of Health Stroke Scale; TIA=transient ischemic attack

Table 2:

Time Metrics Among Ischemic Stroke Patients Treated with Intravenous Thrombolysis (≤4.5 hours onset) Based on Mode of Arrival, 2014–2019

	EMS	Private vehicle
Median (IQR) door to needle time (minutes)	49 (36, 68)	58 (44, 79)
Door to needle time ≤60 minutes N (%)	24501 (67.8)	5079 (54.5)
Door to needle time ≤45 minutes N (%)	15520 (43.0)	2525 (27.1)
Door to needle time ≤30 minutes N (%)	5400 (14.9)	566 (6.1)

Abbreviation: IQR=inter-quartile range

Table 3:

Effect of Emergency Medical Service Arrival versus Private Vehicle on Time Metrics for Ischemic Stroke Patients Receiving Intravenous Thrombolysis ≤4.5 hours onset, 2014–2019

	OR (95% CI)	AOR (95% CI)*
Door to needle time ≤60 minutes	1.76 (1.68–1.84)	1.61 (1.53–1.69)
Door to needle time ≤45 minutes	2.03 (1.93–2.13)	1.88 (1.78–1.98)
Door to needle time ≤30 minutes	2.72 (2.48–2.97)	2.53 (2.31–2.78)

*Adjusted for age, sex, race/ethnicity, insurance, and NIHSS score.

Table 4:

Factors Associated with Emergency Medical Services Utilization for Acute Stroke Care, 2014–2019

	OR (95% CI)	AOR (95% CI)*
Age (years)		
18–64	0.56 (0.55–0.57)	0.67 (0.66–0.68)
≥65	Ref	Ref
Sex		
Women	1.20 (1.19–1.22)	1.06 (1.05–1.07)
Men	Ref	Ref
Race/ethnicity		
Non-Hispanic Black	0.97 (0.95–0.98)	1.04 (1.03–1.06)
Hispanic	0.74 (0.72–0.76)	0.76 (0.74–0.79)
Other race/ethnicity	0.91 (0.89–0.93)	0.85 (0.83–0.88)
Non-Hispanic White	Ref	Ref
Presenting stroke severity (NIHSS score)		
≤10	0.129 (0.125–0.133)	0.138 (0.134–0.142)
11–20	Ref	Ref
>20	5.74 (5.42–6.07)	2.29 (2.15–2.44)
Insurance status		
Medicaid	1.40 (1.37–1.43)	1.41 (1.37–1.45)
Medicare	1.81 (1.78–1.83)	1.35 (1.32–1.38)
Self-pay/no insurance	1.03 (0.996–1.06)	1.02 (0.98–1.05)
Private	Ref	Ref
Stroke type		
Hemorrhagic	2.11 (2.07–2.15)	1.47 (1.43–1.51)
TIA	0.73 (0.72–0.74)	0.91 (0.89–0.92)
Ischemic	Ref	Ref

Abbreviations: NIHSS=National Institutes of Health Stroke Scale; TIA=transient ischemic attack

*Adjusted for age, sex, race/ethnicity, NIHSS score, ambulatory status prior to admission, insurance status, and stroke type.

Table 5:

Trends in Utilization of Emergency Medical Services for Acute Stroke Care by Year, 2014–2019

	2014	2015	2016	2017	2018	2019	P for trend
EMS utilization (%)	59.6%	59.7%	60.4%	60.8%	59.5%	59.3%	0.037
Pre-notification among utilization of EMS (%)	56.9%	56.5%	54.1%	54.7%	56.4%	56.5%	0.99
Among Ischemic stroke (%)	59.3%	59.3%	60.0%	60.0%	58.6%	58.1%	<0.0001
Among TIA (%)	51.3%	50.8%	51.9%	52.9%	50.7%	51.1%	0.89
Among Hemorrhagic stroke (%)	75.5%	75.4%	75.2%	76.0%	74.6%	75.3%	0.44

Abbreviation: EMS=emergency medical services; TIA=transient ischemic attack