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Patterns of Emergency Medical Services Use and Its Association With Timely Stroke Treatment

Findings From Get With the Guidelines-Stroke

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Background—Prior studies found that only about half of stroke patients arrived at hospitals via emergency medical services (EMSs), yet since then, there have been efforts to increase public awareness that time is brain. Using contemporary Get With the Guidelines-Stroke data, we assessed nationwide EMS use by stroke patients.

Methods and Results—We analyzed data from 204 591 patients with ischemic and hemorrhagic stroke admitted to 1563 Get With the Guidelines-Stroke participating hospitals with data on National Institute of Health Stroke Score and insurance status. Hospital arrival by EMSs was observed in 63.7% of patients. Older patients, those with Medicaid and Medicare insurance, and those with severe stroke were more likely to activate EMSs. In contrast, minority race and ethnicity and living in rural communities were associated with decreased odds of EMS use. EMS transport was independently associated with earlier arrival (onset-to-door time, ≤3 hours; adjusted odds ratio, 2.00; 95% confidence interval, 1.93–2.08), prompter evaluation (more patients with door-to-imaging time, ≤25 minutes; odds ratio, 1.89; 95% confidence interval, 1.78–2.00), more rapid treatment (more patients with door-to-needle time, ≤60 minutes; odds ratio, 1.44; 95% confidence interval, 1.28–1.63), and more eligible patients to be treated with tissue-type plasminogen activator if onset is ≤2 hours (67% versus 44%; odds ratio, 1.47; 95% confidence interval, 1.33–1.64).

Conclusions—Although EMS use is independently associated with more rapid evaluation and treatment of stroke, more than one third of stroke patients fail to use EMSs. Interventions aimed at increasing EMS activation should target populations at risk, particularly younger patients and those of minority race and ethnicity. **(*Circ Cardiovasc Qual Outcomes*. 2013;6:262-269.)**

Key Words: emergency medical services ■ Get With the Guidelines-Stroke ■ stroke

Since the introduction of thrombolytic therapy for ischemic stroke, public health authorities and clinical facilities have sought effective ways to reach stroke victims rapidly for evaluation and treatment.[1,2] Delayed time to presentation of acute stroke patients has precluded the use of thrombolytics in many acute ischemic stroke patients.[3,4] Activation of emergency medical services (EMSs) has been identified as an effective way for stroke patients to reduce symptom onset to hospital arrival.[5–10] EMS transportation may enhance prenotification of the receiving hospital, activation of the stroke team, and facilitation of early brain imaging and administration of thrombolytic therapy.[7–10] There has been efforts aimed to increase public awareness that time is brain, recognize the potential signs and symptoms of stroke, and activate EMSs.[11,12]

Prior studies have suggested that only about half of acute stroke patients were transported to the hospital via EMSs.[13–16] Most of these studies were based on data collected more than a decade ago, involved only particular regions of the United States, or involved modest numbers of patients. No study has looked at the patterns of EMS use in stroke using contemporary national datasets. Because of its size, national scope, and duration, the Get With the Guidelines-Stroke (GWTG-Stroke) registry provides an ideal opportunity to examine contemporary patterns of EMS use in stroke.[17,18]

The objectives of this study were to (1) describe the population of stroke patients transported to the hospital via EMSs, (2) determine whether disparities exist in EMS activation by stroke patients, and (3) compare timeliness of

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WHAT IS KNOWN

- There is increased public awareness that time is brain. Emergency medical services (EMSs) are recognized as an effective way to transport patients quickly to the hospital.
- Prior studies based on data collected more than a decade ago involving some particular regions of the United States and only modest numbers of patients indicated that only about half of acute stroke patients are transported to the hospital via EMSs.
- The Get With the Guidelines-Stroke program, developed by the American Heart Association/American Stroke Association as a national stroke registry and performance improvement program, provides a contemporary resource to assess the patterns of EMS use in acute stroke.

WHAT THE STUDY ADDS

- Among stroke patients admitted into hospitals participating in the Get With the Guidelines-Stroke program, with >1 million enrollees, EMS use was associated with more rapid evaluation and treatment of stroke; however, more than one-third still fail to use EMSs. Although older patients, those with Medicaid and Medicare insurance, and those with severe stroke were more likely to activate EMSs, being members of minority race/ethnicity and living in rural communities were associated with decreased odds of EMS use.
- This study supports interventions targeted at populations at risk, particularly younger patients and those of minority race and ethnicity.

arrival, evaluation, and treatment of stroke between those who arrived by EMSs and those who did not.

Methods

GWTG-Stroke Registry

The GWTG-Stroke program was developed by the American Heart Association/American Stroke Association as a national stroke registry and performance improvement program with the primary goal of improving the quality of care and outcomes for stroke and transient ischemic attack (TIA), as well as serve as a scientific resource for new information.[17,18] The methods of case ascertainment and data collection have been previously reported.[17,18] Briefly, the sample consisted of consecutive patients admitted with acute stroke by either prospective clinical identification or retrospective identification using *International Classification of Diseases* (*ICD*)*-Ninth Revision* discharge codes. Data were abstracted by trained hospital personnel using an Internet-based Patient Management Tool. The abstracted data included demographics, medical history, initial head computerized tomography or medical resonance imaging timing, in-hospital treatment and events, discharge treatment and counseling, mortality, and discharge destination.[17–19] Outcome Sciences, Inc serves as the data collection (through their Patient Management Tool) and coordination center for GWTG programs. The Duke Clinical Research Institute serves as the data analysis center and has an agreement to analyze the aggregate deidentified data for research purposes.

Study Population

The population for this study consisted of all patients enrolled in the 1563 hospitals participating in the GWTG-Stroke registry between April 1, 2003, and June 30, 2010. We excluded TIA patients (n=285 850), patients transferred from another hospital (n=178 819), and patients with no information on mode of transportation to the hospital (n=72 735). After the exclusions, an initial cohort of 732 501 ischemic and hemorrhagic stroke admissions was assembled. To allow for broad analysis of factors that may influence EMS activation in this large cohort of acute stroke patients, we further excluded patients without documented National Institute of Health Stroke Score (NIHSS; n=399 403) and patients with no information on insurance status (n=128 507). The final analysis sample consisted of 204 591 patients (Figure 1). Additional sensitivity analyses were conducted on subgroups of the initial cohort to see whether findings will be different from the primary cohort.

Study Outcome and Key Independent Variables

The main outcome of interest was EMS use. We defined EMS use as transportation from home or from scene of onset of symptoms by ambulance. Non-EMS use was defined as private transportation, including taxi or any other form of transportation from home or from the scene. Other key outcome measures include process of care measures, such as onset-to-door time, door-to-needle time, onset-to-needle time, door-to-imaging time, and use of intravenous tissue-type plasminogen activator (IV tPA), in eligible patients arriving ≤2 hours and treated ≤3 hours and use in eligible patients arriving ≤3.5 hours and treated ≤4.5 hours. Key independent variables of interest included vulnerable sociodemographic characteristics, such as minority race or ethnicity, insurance as a marker of socioeconomic status, and stroke severity. Insurance status categories included private, Medicare, Medicaid, self-pay, or no insurance. Private insurance was used as the reference insurance status. Stroke severity was stratified on the basis of the NIHSS as follows: <5, 6 to 10, 11 to 15, and >15.[20,21] All other variables have been previously described.[19]

Statistical Analysis

Among the primary cohort of patients with documented NIHSS and insurance status, frequencies and percentages were computed for categorical variables, and mean, median, and percentiles were computed for continuous variables. We compared baseline characteristics according to their mode of transportation to the hospital (EMS use versus non-EMS use). Pearson χ^2 tests were used to evaluate the statistical associations for all categorical variables, and Wilcoxon rank-sum tests were used for all continuous/ordinal variables.

The effect of demographic, clinical, and hospital characteristics on EMS use was further examined using a multivariable logistic regression model with the generalized estimating equations to account for intrahospital clustering. Patient-level covariates examined included age, sex, race/ethnicity, stroke severity, medical history of stroke risk factors and other markers of vascular disease, on or off hour arrival time, and whether stroke onset occurred in a healthcare setting. Hospital characteristics included hospital size, region, type (academic versus nonacademic), and location (urban versus rural). Additional analysis was conducted to determine the effect of EMS use on process of care measures. Besides the standard variable list, annual stroke discharges and annual IV tPA volume were also adjusted for in the model. Interactions of interest were tested, and separate estimates were reported for those that were highly significant. Several sensitivity analyses were also performed. First, we determined factors associated with EMS use in the initial cohort and also coded for patients with missing NIHSS score or insurance to determine whether the findings were similar. We then limited the analyses to acute stroke patients with documented NIHSS and finally to patients who arrived ≤2 hours of onset of symptoms with NIHSS documentation. Temporal trend in EMS use between 2003 and 2010 was assessed among the initial cohort. All tests of hypothesis were 2-tailed with a type-1 error rate fixed at 5%. All statistical analyses were performed using SAS Version 9.1 software (SAS Institute, Cary, NC).

Results

Baseline Characteristics

Among the 204 591 ischemic and hemorrhagic patients, 130 301 (63.7%) were transported to the hospital via EMSs (Table 1).

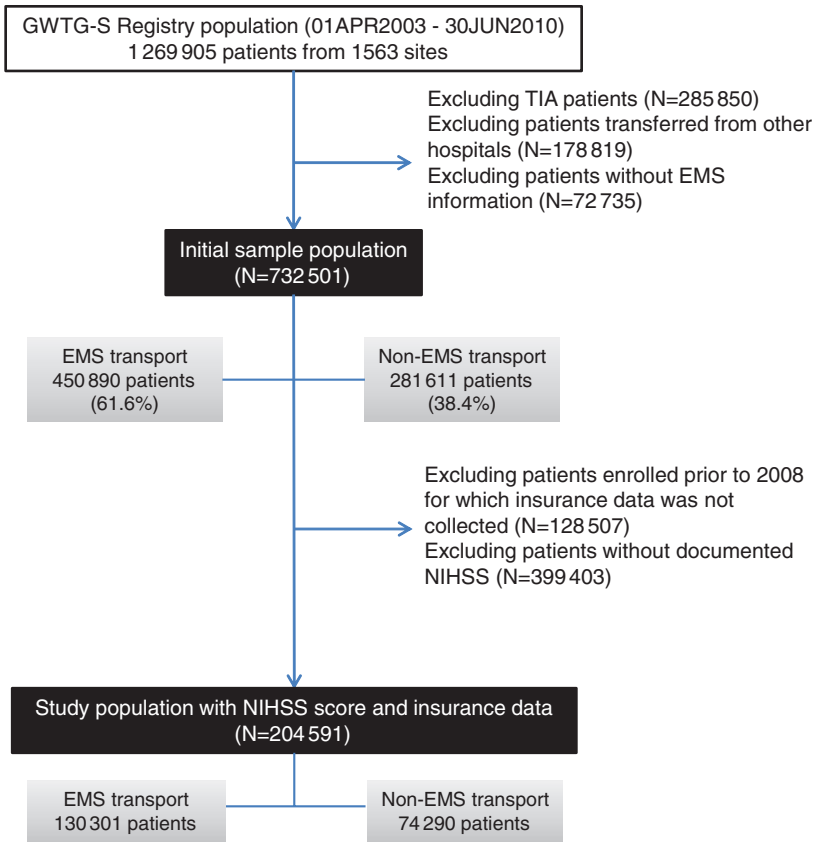

Figure 1. Population flow chart. Initial sample population after exclusions was reduced to population for analysis (patients with National Institute of Health Stroke Score [NIHSS] and insurance data). EMS indicates emergency medical service; GWTG-S, Get With the Guidelines-Stroke; and TIA, transient ischemic attack.

Overall, patients had a mean age of 69.9±14.6 years, 50.4% were women, and 70.5% were non-Hispanic white. Patients who activated EMSs were more likely to possess stroke risk factors and to have more severe stroke (median NIHSS 7 versus 2).

Independent Factors Associated With Emergency Medical Services Use

All sociodemographic and clinical variables that were independently associated with EMS use among persons with stroke severity and documented insurance status are shown in Table 2. Factors associated with EMS use were older age (men, adjusted odds ratio [OR], 1.21; 95% confidence interval [CI], 1.19–1.22; $P<0.0001$ and women, OR, 1.16; 95% CI, 1.14–1.17; $P<0.0001$), those with Medicaid (OR, 1.16; 95% CI, 1.14–1.17; $P<0.0001$), and those with Medicare (OR, 1.16; 95% CI, 1.14–1.17; $P<0.0001$). Notably, there was no association between medical history of previous stroke or TIA and EMS use (OR, 0.99; 95% CI, 0.97–1.01; $P=0.339$). Vulnerable subgroups less likely to use EMSs included minority race or ethnicity and those living in a rural setting. There was a graded positive association between stroke severity by NIHSS and EMS use. All other geographic regions were associated with lower EMS use compared with the Northeast. Similar findings were obtained when the analyses were performed in the entire study population (Appendix Table I in the online-only Data Supplement), those who had documented stroke severity (Appendix Table II in the online-only Data Supplement), and when the analysis was confined to patients arriving ≤2 hours with stroke severity documented (Appendix Table III in the online-only Data Supplement).

Association of Emergency Medical Services With Timely Stroke Treatment

The associations of EMS use with timely stroke arrival, evaluation, and treatment among patients with documented NIHSS and insurance status are presented in Table 3. EMS transport was independently associated with earlier arrival because more patients who used EMSs had onset-to-door time of ≤3 hours (OR, 2.00; 95% CI, 1.93–2.08; $P<0.0001$). Arrival by EMSs was also independently associated with more rapid evaluation. Patients who arrived at the hospital by EMSs were more likely to have computerized tomography or medical resonance imaging performed ≤25 minutes of arrival (OR, 1.89; 95% CI, 1.78–2.00; $P<0.0001$). EMS transport was also independently associated with rapid treatment of patients. More patients who arrived by EMSs had door-to-needle time ≤60 minutes (OR, 1.44; 95% CI, 1.28–1.63; $P<0.0001$) and onset-to-needle time ≤150 minutes (OR, 1.19; 95% CI, 1.08–1.32; $P<0.0001$). Compared with patients who arrived by self-transport, more eligible patients who arrived via EMSs ≤2 hours of onset of symptoms were treated with IV tPA within the 3-hour window (OR, 1.47; 95% CI, 1.33–1.64; $P<0.0001$). Also, more IV tPA eligible patients, who were transported to hospital by EMSs ≤3.5 hours of onset of symptoms, received IV tPA by 4.5 hours of symptom onset (OR, 1.44; 95% CI, 1.36–1.53; $P<0.0001$).

Among patients who arrived ≤2 hours of onset of symptoms, 79% arrived by EMSs. Of this group, 32% were eligible for IV tPA by 3 hours. A total of 67.3% of patients who arrived by EMSs and were eligible for IV tPA received IV tPA ≤3 hours compared with 44.1% among those early arriving patients who did not use EMSs ($P<0.0001$). Other comparison of stroke

Table 1. Baseline Characteristics Comparing Use and Nonuse of Emergency Medical Services Among Stroke Patients With Documented National Institute of Health Stroke Score and Insurance Status (n=204 591)

	Total (n=204 591)	EMS Use (n=130 301)	Non-EMS Use (n=74 290)
Age, y (mean±SD)†	69.9±14.6	71 0.7±14.4	66.9±14.3
25th–75th	60–82	61–83	57–78
Women, %	50.4	51.6	48.4
Race/ethnicity, %			
White	70.5	71.4	68.9
Black	16.3	15.8	17.1
Asian	2.9	2.7	3.3
Hispanic	6.6	6.3	7.1
Rural, %	3.6	3.2	4.3
Insurance status, %			
Self-pay/none	6.9	6.2	8.1
Medicare	33.9	35.9	30.5
Medicaid	7.9	8.3	7.3
Private/others	40.8	38.7	44.6
On-hour arrival (weekdays 7 AM to 6 PM), %	49.4	47.2	53.4
NIHSS, median†	5.0	7.0	2.0
25th–75th	2.0–11.0	3.0–15.0	1.0–5.0
Medical history, %			
Atrial fibrillation/flutter	18.0	21.7	11.5
Prior stroke/TIA	31.5	31.8	31.0
CAD/prior MI	26.9	28.1	24.7
Carotid stenosis	3.9	3.8	4.1
Diabetes mellitus	31.8	30.5	34.2
PVD	4.4	4.5	4.3
Hypertension	80.7	81.3	79.6
Smoker	20.6	18.7	23.8
Dyslipidemia	42.2	40.6	44.9
Heart failure	7.5	8.7	5.4
Unable to ambulate, %	2.1	2.8	1.0
Hospital characteristics			
No. of stroke discharges, %†			
≥301	39.3	41.2	36.1
101–300	39.4	38.4	41.2
0–100	8.4	8.0	9.3
No. of beds (median)†	359	366	353
Region, %			
West	18.6	18.5	18.7
South	36.9	36.8	37.1
Midwest	20.2	18.2	23.6
Northeast	24.4	26.5	20.6
Academic hospital, %	51.7	53.8	48.0

On-hour arrival was defined as 7 AM to 5 PM Monday to Friday; all other times (including all day Saturday and Sunday) were considered off-hours. *P* values are based on χ^2 rank–based group mean score statistics for all categorical row variables. All comparisons between EMS and non-EMS are significant at $P<0.05$. CAD/prior MI indicates coronary artery disease/prior myocardial infarction; EMS, emergency medical service; NIHSS, National Institute of Health Stroke Scale; PVD, peripheral vascular disease; and TIA, transient ischemic attack.

†*P* values are based on χ^2 rank–based group mean score statistics for all continuous/ordinal row variables (equivalent to Wilcoxon tests). All tests treat the column variable as nominal (overall column excluded).

evaluation and treatment by EMS use among all patients who presented ≤2 hours of onset of symptoms, including those with missing data on NIHSS or insurance, is presented in Table 4.

Differences in demographics and clinical characteristics between patients with documented mode of transportation and those without this documentation were modest (Appendix

Table 2. Factors Associated With Emergency Medical Services Use Among Stroke Patients With Documented National Institute of Health Stroke Score and Insurance Status (n=185 997)**

	EMS Use (n=118 837)	Non-EMS (n=67 160)	Adjusted Odds Ratio	95% Confidence Interval
Age (per 10-y increase) among women (mean±SD)*	74.2±14.3	68.5±15.0	1.21	1.19–1.22
Age (per 10-y increase) among men (mean±SD)*	69.0±14.0	65.6±13.6	1.16	1.14–1.17
Race/ethnicity (ref, non-Hispanic white), %	71.4	68.9		
Black*	15.6	17.0	0.87	0.83–0.91
Hispanic*	6.2	6.9	0.73	0.69–0.77
Asian*	2.7	3.2	0.67	0.62–0.72
Others	3.6	3.4	0.95	0.88–1.03
Rural (ref, urban), %†	3.1	4.1	0.85	0.74–0.97
Medical history, %				
Atrial fibrillation/flutter*	21.7	11.5	1.37	1.33–1.42
Previous stroke/TIA	31.8	31.0	0.99	0.97–1.01
CAD/prior MI*	28.4	24.7	1.10	1.07–1.13
Carotid stenosis†	3.9	4.2	0.93	0.88–0.98
Diabetes mellitus*	30.4	34.1	0.95	0.93–0.97
Hypertension†	81.3	79.5	1.04	1.02–1.07
Dyslipidemia*	40.8	45.2	0.90	0.88–0.92
Insurance (ref, private), %	38.7	44.6		
Medicaid*	8.2	7.2	1.21	1.15–1.28
Medicare*	36.0	30.6	1.06	1.03–1.09
Self-pay/no insurance	6.3	8.1	1.01	0.95–1.07
On-hour arrival (weekdays 7 AM to 6 PM), %*	47.1	53.4	0.82	0.80–0.84
National Institute of Health Stroke Scale (ref, ≤5), %				
6–10*	20.4	13.6	2.65	2.57–2.73
11–15*	13.2	3.7	5.72	5.45–6.01
>15*	24.2	3.1	11.50	10.84–12.20
Region (ref, Northeast), %				
Midwest*	17.5	22.9	0.61	0.54–0.69
South†	37.5	37.9	0.81	0.72–0.91
West†	17.7	17.8	0.82	0.71–0.96
No. of beds (per 100 increase), median†	367	353	1.04	1.02–1.06
Academic hospital (ref, nonacademic), %*	57.6	51.8	1.22	1.11–1.34

CAD/prior MI indicates coronary artery disease/prior myocardial infarction; CI, confidence interval; EMS, emergency medical service; and TIA, transient ischemic attack.
*$P<0.0001$; †$P<0.05$.
**Patients with missing hospital characteristics were excluded.

Table IV in the online-only Data Supplement). Analysis that included all stroke patients with an additional covariate for those patients with missing NIHSS or insurance indicated that patients with either NIHSS or insurance missing were less likely to be transported by EMSs, but the relationship for the other covariates was the same or similar (Appendix Table V in the online-only Data Supplement). Overall, EMS use in the initial cohort (n=732 501) was 61.7%. The temporal trend in EMS use from 2003 to 2010 is presented in Figure 2.

Discussion

Key Findings

To the best of our knowledge, this is the largest and most comprehensive study to date that has looked at the patterns of EMS use in stroke, analyzing contemporary nationwide data. The findings from the current analysis demonstrate that in a large national registry of stroke patients, more than one third of acute stroke patients did not activate EMSs. In addition, we found that certain subgroups of patients were particularly less likely to use EMSs, including patients of minority race or ethnicity and those living in rural communities. The relationship of EMS use with insurance status was inconsistent. Importantly, previous history of stroke or TIA did not translate to increased EMS activation. Finally, we found that patients who used EMSs had shorter prehospital and in-hospital delay, experienced faster times in evaluation and treatment, and were more likely to be treated with IV tPA when eligible.

Underutilization of Emergency Medical Services

Studies based on data collected >10 years ago from different regions of the United States and a recent nationally representative sample of emergency department visits showed

Table 3. Association of Stroke Arrival, Evaluation, and Treatment With Emergency Medical Service Use Among Patients With Documented National Institute of Health Stroke Score and Insurance Status (n=204 591)

	EMS Use (n=130 301)	Non-EMS Use (n=74 290)	Unadjusted OR	95% CI	Adjusted OR	95% CI
Onset-to-door time ≤3 h	60.8	40.0	2.28	2.20–2.36	2.00	1.93–2.08
Door-to-needle time ≤1 h	28.4	21.4	1.51	1.35–1.70	1.44	1.28–1.63
Onset-to-needle time ≤2.5 h	59.6	52.5	1.34	1.23–1.47	1.19	1.08–1.32
Door to CT or MRI time ≤25 min (if onset to door ≤3 h)	54.7	35.6	2.26	2.14–2.38	1.89	1.78–2.00
Treatment with IV tPA by 3 h (if onset to door ≤2 h)	85.4	68.2	2.11	1.94–2.30	1.47	1.33–1.64
Treatment with IV tPA by 4.5 h (if onset to door ≤3.5 h)	40.7	21.2	2.37	2.25–2.50	1.44	1.36–1.53

Adjusted for age, sex, race, insurance, history of atrial fibrillation/flutter, prosthetic heart valve, previous stroke/TIA, CAD/prior MI, carotid stenosis, diabetes mellitus, PVD, hypertension, smoker, dyslipidemia, heart failure, on-time arrival, NIHSS, hospital size, hospital type, region, rural/urban, annual IV tPA volume, and annual stroke volume. All *P* values are significant at $P<0.0001$. CAD/prior MI indicates coronary artery disease/prior myocardial infarction; CI, confidence interval; CT, computerized tomography; IV tPA, intravenous tissue-type plasminogen activator; MRI, medical resonance imaging; NIHSS, National Institute of Health Stroke Scale; OR, odds ratio; PVD, peripheral vascular disease; and TIA, transient ischemic attack.

that only about half of stroke patients are transported to the hospital via EMSs.[13–16] In this contemporary national cohort of stroke patients, EMS use still remains suboptimal. More than one third of stroke patients still make it to the hospital by self-transport in spite of concerted public health efforts.[11,12]

The decreased use of EMSs as a means of transportation to the hospital during events by members of minority race and ethnicity is striking. This finding may represent another example of a disparity in the stroke field.[22] However, unlike other disparities, this may not be associated with physician or system factors because it is an action required to be taken by the patient. A possible explanation may be the fear of financial responsibility for the EMS transport bill. It may also be related to stroke education or possibly a cultural factor, such as system mistrust, and would require further investigation beyond what is available in GWTG-Stroke. This group should be the target of enhanced community education interventions to reduce prehospital delay associated with nonuse of EMSs.

Consistent with what has been reported in other studies,[15,23,24] we found that previous history of stroke or TIA did not confer greater likelihood of EMS activation during subsequent stroke, indicating potential missed opportunities to educate stroke or TIA patients on the need for EMS transportation at future symptom onset. Information on the emergency nature of stroke and the need to call 911 at the onset of symptoms is now included as part of stroke education and discharge recommendations for stroke patients, and this activity is covered in certification of primary stroke centers as measure STK-8.[25] STK-8 is a stroke education discharge recommendation for stroke patients. Conformity with this measure required that patients with ischemic or hemorrhagic stroke or their caregivers are given education and educational materials during the hospital stay addressing risk factors for stroke, warning signs for stroke, activation of EMSs, need for follow-up after discharge, and medications prescribed at discharge.

Patients with private insurance used EMSs less frequently than those with Medicare or Medicaid, and there was no difference in use between private insurance and no insurance groups. Private insurance may not be a precise surrogate for socioeconomic status or ability to pay for EMSs because financial liability associated

Table 4. Comparison of Stroke Evaluation and Treatment by Emergency Medical Services Use Among Patients Arriving ≤2 Hours of Onset of Symptoms (n=148 854)

	Total (n=148 854)	EMS Use (n=117 125)	Non-EMS Use (n=31 729)
Onset-to-door time, min* (median)	58.0	57.0	60.0
25th–75th	39.0–80.0	40.0–78.0	35.0–86.0
Door-to-CT or -MRI time, min* (median)	30.0	28.0	39.0
25th–75th	18.0–52.0	16.0–48.0	23.0–70.0
Onset-to-IV tPA time, min* (median)	140.0	140.0	143.5
25th–75th	114.0–165.0	114.0–164.0	115.0–168.0
Treatment with IV tPA (overall)	33 209 (22.3)	28 962 (24.7)	4247 (12.8)
Eligible patients for IV tPA by 3 h	47 608 (32.0)	39 142 (33.4)	8466 (26.7)
Patients treated with IV tPA by 3 h (if onset to door ≤2 h)	30 065 (63.2)	26 336 (67.3)	3729 (44.1)

All comparisons between EMS and non-EMS are significant at $P<0.0001$. CT indicates computerized tomography; EMS, emergency medical service; IV tPA, intravenous tissue-type plasminogen activator; and MRI, medical resonance imaging.

**P* values are based on χ^2 rank–based group mean score statistics for all continuous/ordinal row variables (equivalent to Wilcoxon tests). All tests treat the column variable as nominal.

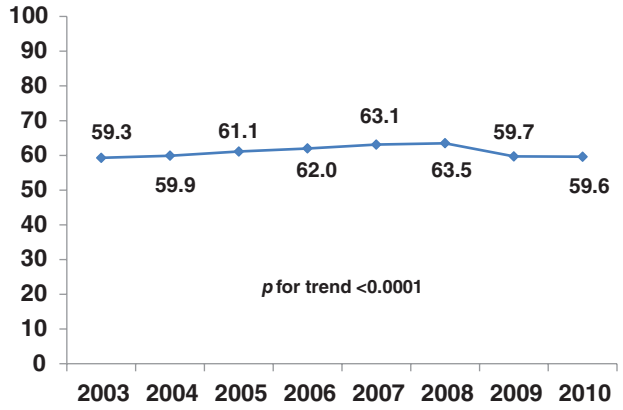

Figure 2. Temporal trend in emergency medical service use 2003–2010.

with use of EMSs may vary across plans and geographic regions. Similar findings were reported in studies among acute myocardial infarction patients, indicating that underinsurance, a situation that may require a large out-of-pocket payments, may actually be a major economic consideration that affects EMS activation.[26,27]

Impact of EMS Activation

Our results show that EMS transportation is independently associated with more timely brain imaging, greater administration of thrombolytics for eligible patients, and more rapid thrombolytic treatment and may, as a result, enhance better long-term outcomes. Administration of thrombolytic therapy to eligible patients ≤2 hours of onset of symptoms is associated with minimal or no disability at 3 months in ≥30% of acute ischemic stroke patients.[1]

Need for Improved EMS Activation in Stroke Care

Delay in activating EMSs by patients who are experiencing symptoms of stroke has been found to be the most important factor in failure to provide thrombolytic treatment within the eligibility window.[1,2,28] Only a few interventions have been designed and tested at the community level to both increase public stroke knowledge and impact behavior that will lead to earlier hospital arrival for treatment.[2,29–34] Most of these studies have shown that community-based education campaign interventions using the media can increase community awareness of the warning signs for stroke and the need to activate EMSs when these symptoms develop.[2,29–33] Only 1 recent study reported no change after 4 years of educational campaign.[34]

Although these studies focused on the general public, findings from our study further suggest that intervention specifically directed at minority populations at the community level is required and may be important for the overall improvement of EMS activation in the setting of acute stroke. The Center for Disease Control and Prevention has called for more extensive public education on the early recognition of stroke and the urgent need to call 911 to receive EMS transport to the hospital.[35]

Limitations

This study has some limitations that need to be acknowledged. First, it is based on observational data, and findings may be limited by residual measured and unmeasured confounders. Second, information on patient income and educational level was not available. These socioeconomic status variables may be important determinants of EMS activation. Although we used insurance status as a proxy for socioeconomic status, it may not be an appropriate surrogate. Third, we do not have data on patients' place of residence. As a result, we could not assess the effect of neighborhood characteristics on EMS use. However, a recent study that looked at the association of EMS use in patients with myocardial infarction reported that EMS transportation is associated with shorter prehospital delay regardless of geographic distance from the hospital.[25] Further studies are required to determine the role of distance on EMS activation. Patients with missing information on mode of transportation and NIHSS were excluded from the analysis, which may introduce bias. Hospitals participating in GWTG-Stroke are self-selected and tend to be larger, teaching institutions and have an interest in stroke quality improvement. Findings from this study, therefore, may not be representative of patients arriving at other US hospitals. Finally, factors such as living alone, symptom denial, embarrassment, awareness of available resources, and cultural factors (eg, feeling like one has little or no control) were not available in the GWTG-Stroke but may influence EMS activation.[11]

Conclusions

Among a large contemporary population of patients presenting with acute stroke, EMS usage seems to be higher than in prior studies but still remains low, as more than one-third of strokes fail to be transported to the hospital by EMSs. Our findings indicate that EMS activation may potentially improve treatment in acute stroke by reducing delays associated with time to hospital presentation and provision of appropriate evaluation and treatment. Young and minority patients are sociodemographic groups that are more likely to underuse EMSs and should be the target of interventions to improve EMS activation.

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Appendix Table 1. Factors Associated with Emergency Medical Services Use Among All Stroke Patients (N=681,488)

	Adjusted Odds Ratio	95% Confidence Interval
Age (per 10-year increase) among female*	1.29	1.28 – 1.30
Age (per 10-year increase) among male*	1.18	1.17 – 1.19
Race/ethnicity (ref=non-Hispanic white)		
Black	0.99	0.96 – 1.02
Hispanic*	0.84	0.81 – 0.87
Asian*	0.85	0.82 – 0.89
Others	0.96	0.91 – 1.01
Rural (ref=urban)	0.94	0.87 – 1.01
Medical History		
Atrial fibrillation/flutter*	1.59	1.56 – 1.61
Stroke/ transient ischemic attack*	1.09	1.08 – 1.11
Coronary artery disease or prior myocardial infarction*	1.13	1.11 – 1.14
Carotid stenosis*	0.82	0.79 – 0.85
Diabetes mellitus*	0.95	0.94 – 0.96
Peripheral vascular disease*	1.08	1.05 – 1.11
Hypertension	1.01	1.00 – 1.03
Dyslipidemia*	0.79	0.78 – 0.80
Arrival on-hours (ref=off hours)*	0.78	0.77 – 0.79
Patient location (not in a healthcare setting) *	1.71	1.57 – 1.87
Region (ref=north east)		
Midwest *	0.78	0.72 – 0.85
South†	0.88	0.82 – 0.95
West	1.00	0.91 – 1.10
Number of beds (per 100 increase) *	1.05	1.03 – 1.06
Academic hospital (ref=nonacademic) *	1.14	1.07 – 1.21

*p<0.0001.
†p<0.05.

Table 2. Factors Associated with Emergency Medical Services Use Among Stroke Patients With Documented NIHSS (N=313,213)

	EMS use (n=200,764)	Non-EMS use (n=112,449)	Adjusted Odds Ratio	95% Confidence Interval
Age (per 10-year increase) among female, (mean ± SD)*	74.7 ± 14.2	68.6 ± 15.0	1.24	1.22 – 1.25
Age (per 10-year increase) among male, (mean ± SD)*	69.3 ± 13.9	65.7 ± 13.6	1.17	1.16 – 1.18
Race/ethnicity (ref=non-Hispanic white), %				
Black*	14.8	16.3	0.90	0.86 – 0.94
Hispanic*	5.3	6.2	0.73	0.70 – 0.77
Asian*	2.7	3.3	0.69	0.65 – 0.74
Others†	4.1	4.2	0.89	0.83 – 0.97
Rural (ref=urban), %†	2.8	3.7	0.81	0.72 – 0.91
Medical history, %				
Atrial fibrillation/flutter*	22.5	11.7	1.38	1.34 – 1.41
Coronary artery disease/prior myocardial infarction*	29.3	25.1	1.11	1.09 – 1.14
Carotid stenosis*	4.0	4.4	0.91	0.88 – 0.95
Diabetes mellitus*	29.8	33.1	0.96	0.94 – 0.98
Hypertension†	80.7	79.3	1.04	1.02 – 1.06
Dyslipidemia*	39.1	44.2	0.88	0.87 – 0.90
On-hour arrival (weekdays 7am-6pm)*	47.4	52.8	0.82	0.81 – 0.84
National institute of health stroke scale (ref=≤5), %				
6-10*	20.8	13.8	2.71	2.64 – 2.78
11-15*	13.7	3.9	5.72	5.49 – 5.97
>15*	24.2	3.2	11.29	10.75 – 11.86
Region (ref=northeast), %				
Midwest*	17.7	22.8	0.63	0.57 – 0.71
South†	37.4	37.7	0.85	0.76 – 0.94
West†	18.1	18.3	0.85	0.74 – 0.99
Number of beds (per 100 increase), median†	374	358	1.03	1.01 – 1.05
Academic hospital (ref=nonacademic), %*	58.7	53.5	1.22	1.12 – 1.33

*p<0.0001.
†p<0.05.

Appendix Table 3. Factors Associated with Emergency Medical Services Use Among Stroke Patients Arriving Within Two Hours With Documented NIHSS (N = 90,578)

	Adjusted Odds Ratio	95% Confidence Interval
Age (per 10-year increase) among female*	1.24	1.22 – 1.26
Age (per 10-year increase) among male*	1.17	1.15 – 1.20
Race/ethnicity (ref=non-Hispanic white)		
Black	1.05	0.97 – 1.13
Hispanic†	0.86	0.79 – 0.94
Asian	0.91	0.81 – 1.03
Others	0.95	0.85 – 1.07
Rural (ref=urban) †	0.76	0.65 – 0.89
Medical history		
Atrial fibrillation/flutter*	1.23	1.17 – 1.29
Stroke/ transient ischemic attack*	0.88	0.84 – 0.91
Coronary artery disease/prior myocardial infarction†	1.06	1.02 – 1.11
Carotid stenosis	0.94	0.86 – 1.03
Hypertension†	1.08	1.04 – 1.13
Smoking	1.05	1.00 – 1.09
Dyslipidemia*	0.83	0.80 – 0.86
Arrival on-hours (ref=off hours)*	0.95	0.91 – 0.84
Patient location (not in a healthcare setting)*	1.71	1.32 – 2.22
National institute of health stroke scale (ref=≤5)		
6-10 *	2.42	2.31 – 2.53
11-15*	4.48	4.21 – 4.47
>15*	7.27	6.82 – 7.75
Region (ref=north east)		
Midwest *	0.64	0.57 – 0.71
South†	0.86	0.77 – 0.97
West†	0.85	0.74 – 0.97
Number of beds (per 100 increase) †	1.04	1.02 – 1.07
Academic hospital (ref=nonacademic) *	1.22	1.11 – 1.34

*p<0.0001.
†p<0.05.

Appendix Table 4. Characteristics of Patients With or Without Documented Means of Transportation (N=805,236)

	Total (N = 805,236)	Mode of transportation documented (n = 732,501)	Mode of transportation missing (n = 72,735)
Age years, mean ± SD† (female)	72.4 ± 15.0	72.6 ± 14.9	70.6 ± 15.3
Age years, mean ± SD† (male)	67.9 ± 14.2	68.0 ± 14.2	67.2 ± 14.1
Female, %	51.9	51.9	48.4
Race/ethnicity, %			
White	70.8	70.9	69.7
Black	16.1	16.1	15.5
Asian	2.7	2.7	2.2
Hispanic	5.8	5.9	4.9
Rural, %	3.8	3.8	2.9
Insurance status, %			
Self-pay/none	3.9	4.1	1.8
Medicare	20.5	21.5	9.9
Medicaid	4.5	4.8	1.6
Private/others	23.3	24.6	10.6
Arrival on-hours, %	47.4	48.9	32.8
NIHSS, median†	5.0	5.0	4.0
25^{th}-75^{th}	2.0-11.0	2.0-11.0	2.0-10.0
Medical history, %			
Atrial fibrillation/flutter	17.9	18.0	16.9
Stroke/TIA	31.7	31.9	29.6
CAD/Prior MI	27.6	27.6	28.1
Carotid stenosis	4.3	4.2	5.7
Diabetes mellitus	31.8	31.8	31.8
PVD	4.9	4.8	5.7
Hypertension	80.2	80.3	78.5
Smoker	20.2	20.0	22.4
Dyslipidemia	39.1	39.1	39.8
Heart failure	4.3	4.4	3.2
Unable to ambulate, %	1.9	2.0	1.1
Hospital characteristics			
No. of stroke discharges, %†			
301+	38.9	39.0	38.0
101 – 300	38.5	38.4	39.0
0 – 100	8.9	9.1	7.1
Number of beds, median†	366	365	399
Region, %			
West	17.7	17.9	15.1
South	38.4	37.8	44.6
Midwest	18.7	18.6	19.4
Northeast	25.3	25.7	20.9
Academic hospital, %	56.6	56.0	62.4

CAD/Prior MI indicates coronary heart disease or myocardial infarction; NIHSS, national institute of health stroke scale; PVD, peripheral vascular disease.

p values are based on chi-square rank based group means score statistics for all categorical row variables.
†*p* values are based on chi-square rank based group means score statistics for all continuous/ordinal row variables (equivalent to Wilcoxon tests). All tests treat the column variable as nominal (overall column excluded).
All comparisons are significant at $p<0.05$ except for diabetes mellitus
On-hour arrival was defined as 7 AM to 5 PM Monday to Friday; all other times (including all day Saturday and Sunday) were considered off-hours.

Appendix Table 5. Factors Associated with Emergency Medical Services Use Among All Stroke Patients With Coding for Missing NIHSS Score and Insurance (N=681,488)

	Adjusted Odds Ratio	95% Confidence Interval
Age (per 10-year increase) among female*	1.29	1.28 – 1.30
Age (per 10-year increase) among male*	1.18	1.18 – 1.19
Race/ethnicity (ref=non-Hispanic white)		
Black	0.99	0.96 – 1.02
Hispanic*	0.84	0.81 – 0.87
Asian*	0.85	0.82 – 0.89
Others	0.97	0.92 – 1.02
Rural (ref=urban)	0.95	0.88 – 1.02
Medical history		
Atrial fibrillation/flutter*	1.58	1.56 – 1.61
Stroke/ transient ischemic attack*	1.09	1.08 – 1.11
Coronary artery disease/prior myocardial infarction*	1.13	1.11 – 1.14
Carotid stenosis*	0.82	0.79 – 0.85
Diabetes mellitus*	0.95	0.94 – 0.96
Peripheral vascular disease*	1.08	1.06 – 1.11
Hypertension	1.01	1.00 – 1.02
Dyslipidemia*	0.78	0.77 – 0.79
Arrival on-hours (ref=off hours)*	0.78	0.77 – 0.79
Patient location (not in a healthcare setting)*	1.75	1.60 – 1.92
Patients missing NIHSS or Insurance*	0.88	0.85 – 0.91
Region (ref=north east)		
Midwest *	0.78	0.72 – 0.74
South†	0.88	0.82 – 0.95
West	1.00	0.91 – 1.10
Number of beds (per 100 increase)*	1.05	1.03 – 1.06
Academic hospital (ref=nonacademic) *	1.15	1.08 – 1.22

*p<0.0001.
†p<0.05.