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Association Between Dispatch Complaint and Critical Prehospital Time Intervals in Suspected Stroke 911 Activations in the National Emergency Medical Services Information System, 2012-2016

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Structured Abstract

Objective.—Emergency Medical Services can help improve stroke outcomes by recognizing stroke symptoms, establishing response priority for 911 calls, and minimizing prehospital delays. This study examines 911 stroke events and evaluates associations between events dispatched as stroke and critical EMS time intervals.

Materials and Methods.—Data from the National Emergency Medical Services Information System, 2012 to 2016, were analyzed. Activations from 911 calls with a primary or secondary provider impression of stroke were included for adult patients transported to a hospital destination. Three prehospital time intervals were evaluated: 1) response time (RT) ≤8 minutes, 2) on-scene time (OST) ≤15 minutes, and 3) transport time (TT) ≤12 minutes. Associations between stroke dispatch complaint and prehospital time intervals were assessed using multivariate regression to estimate adjusted risk ratios (ARR) and 95% confidence intervals (CIs).

Results.—Approximately 37% of stroke dispatch complaints were identified by EMS as a suspected stroke. Compared to stroke events without a stroke dispatch complaint, median OST was shorter for events with a stroke dispatch (16 minutes vs. 14 minutes, respectively). In adjusted analyses, events dispatched as stroke were more likely to meet the EMS time benchmark for OST ≤15 minutes (OST, 1.20 [1.20-1.21]), but not RT or TT (RT, [1.00-1.01]; TT, 0.95 [0.94-0.95]).

Conclusions.—Our results indicate that dispatcher recognition of stroke symptoms reduces the time spent on-scene by EMS personnel. These findings can inform future EMS stroke

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education and quality improvement efforts to emphasize dispatcher recognition of stroke signs and symptoms, as EMS dispatchers play a crucial role in optimizing the prehospital response.

Keywords

Stroke; prehospital time; EMS; Emergency Medical Services

Introduction

Stroke, one of the leading causes of death and disability in the United States (US), is a time sensitive emergency (1). Receiving timely treatment is associated with increased survival and better outcomes (2-5). For every minute that treatment is delayed, a patient with stroke may lose an estimated 1.9 million neurons, leading to irreversible brain tissue damage long term disability, or death (6). Several studies have demonstrated that treatment with intravenous recombinant tissue-type plasminogen activator (IV alteplase) can positively affect clinical outcomes when administered within a critical timeframe after ischemic stroke symptom onset (2, 4, 5). Due to the time-dependent benefit of IV alteplase and other stroke treatments, like endovascular thrombectomy, one of the primary links in the chain of treatment and recovery is an efficient response by Emergency Medical Services (EMS) (7-9). The American Heart Association/American Stroke Association's (AHA/ASA) policy statement on implementation strategies for EMS established several recommendations to ensure timely access to stroke care (7). These recommendations include rapid activation and dispatch at the highest level of care available for suspected strokes and ensuring a rapid, efficient EMS response time, on-scene time, and transport to the most appropriate hospital. A more efficient EMS response across these prehospital time intervals may result in patients arriving more quickly to the hospital, improving their stroke treatment options and health outcomes.

Efforts to reduce prehospital delays are critical in supporting timely treatment for suspected stroke patients. It has been estimated that approximately 50% of stroke patients arrive to the emergency department (ED) by EMS (10). Several factors influence timing within the total prehospital interval – defined as the time from 911 activation to patient arrival at the hospital ED. Studies that have quantified stroke prehospital time intervals generally consider response time, on-scene time, and transport time; of these, on-scene time may be the largest and most modifiable component of the EMS response interval (11-15). EMS dispatchers are important in facilitating a timely and efficient response by EMS in the field. They are the first link in the prehospital care phase, playing a critical role in the recognition of stroke symptoms and identifying a call as stroke-related, establishing the response priority for 911 calls. Therefore, the initial recognition of stroke symptoms by dispatchers may improve the EMS response and lead to faster stroke management across the prehospital care phase.

Few studies have evaluated prehospital time intervals for stroke patients, with most either derived from small sample sizes, conducted outside the US, or analyzed using data from a single hospital system, therefore limiting the generalizability of findings (12, 15-17). The National EMS Information System (NEMSIS) database offers an opportunity to explore nationwide prehospital EMS data for suspected stroke patients. This study aims

to describe response time, on-scene time, and transport time for stroke by patient and event characteristics. This study also aims to evaluate whether stroke dispatch complaint is independently associated with the specified prehospital response intervals.

Methods

Data & Study Population

The National Emergency Medical Services Information System (NEMSIS) is a voluntary national database of patient care reports (PCRs) resulting from an emergency 911 call. NEMSIS is funded by the National Highway Traffic Safety Administration (NHTSA)'s Office of EMS and managed in collaboration with the University of Utah. EMS agencies submit PCR data to their respective state repositories; states then voluntarily submit a subset of data elements to the national database. As of 2016, the NEMSIS registry included 30,206,450 EMS activations submitted by 10,137 EMS agencies serving 49 states and territories. A public-release dataset is available upon request from NHTSA. A more detailed description of NEMSIS has been previously reported elsewhere (18).

NEMSIS version 2 data were analyzed from 2012-2016 and identified patients with primary or secondary provider impression of stroke (referred to herein as suspected stroke event). An EMS provider's impression is a documented element in the PCR that describes the symptom, problem, or condition based on the patient's complaint and the provider's field assessment. This may be documented as primary (or most significant) problem, or a second, less obvious or severe problem with the patient. Version 2 data were chosen as there were changes in the data format after 2017 during the adoption of version 3, which led to widespread missing data across the country as EMS providers onboarded system upgrades. From 2012 to 2016, a total of 129,690,231 EMS activations were reported to NEMSIS (Figure 1). EMS 911 activations were included for patients aged 18 years or older that were treated and transported from the scene to a hospital destination. EMS intercepts, interfacility transfers, medical transports (e.g., scheduled transports for interfacility), mutual aid, and standby events were excluded. EMS activations with missing data on transport times were excluded (8.6%).

Study Variables

As the primary outcome, the following 3 prehospital time intervals were evaluated: 1) response time (RT), defined as the time from EMS unit dispatch to scene arrival, 2) on-scene time (OST), defined as time between EMS scene arrival to EMS departure from the scene, and 3) transport time (TT), defined as the time from EMS scene departure to arrival at the hospital destination. The target benchmarks were defined as ≤8 minutes for RT and ≤15 minutes for OST, based on recommendations published by the AHA/ASA. There are currently no target measures for TT, therefore we categorized TT using the median of the 2012-2016 NEMSIS data which resulted in a measure of ≤12 minutes. Dispatch complaint refers to the condition identified and reported to the responding EMS unit by EMS dispatchers. All conditions other than stroke were classified as "other".

The data for suspected stroke cases and their EMS time intervals of RT, OST, and TT were stratified by gender and race/ethnicity to account for possible demographic differences among prehospital transport times (19, 20). Race and ethnicity categories were collapsed into Black or African American, Hispanic, White, and other. The category “other” is an aggregate of American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, and other race as reported in the PCR by EMS. EMS time intervals were further examined by the following characteristics: age group, urbanicity, dispatch complaint, level of EMS service, basic life support (BLS; staffed by EMTs for basic patient care) or advanced life support (ALS; staffed by paramedics for critical patient care). Age groups were categorized as 18–34, 35–44, 45–54, 55–64, 65-74, 75-84 and 85 years and older. Categories of urbanicity (urban, suburban, rural, wilderness) were approximated using responding EMS agency zip codes that linked to U.S. Department of Agriculture (USDA) Urban Influence Codes (21).

Statistical Analysis

Percentages of stroke events for each group of characteristics for the specified time intervals were calculated. Chi-square tests were used to assess differences across characteristics. To measure associations between dispatch complaint and EMS time measures, we used multivariate regression to obtain adjusted risk ratios (ARRs) and their 95% confidence intervals (CIs). The following variables were entered in adjusted models based on prior literature: gender, age, race/ethnicity, and level of service. All statistical analyses were conducted using SAS v9.4 (SAS Institute Inc., NC) and our hypothesis testing was considered significant at $p < 0.01$.

Results

There were 61,500,757 EMS 911 activations that included patients aged 18 years or older who were treated and transported from the scene to a hospital destination. Of these, 1,057,341 (1.7%) had a primary or secondary EMS provider impression of stroke; 90,596 had missing response times, therefore, 966,745 patients were included in the analysis. Demographic data and main characteristics of suspected stroke events are shown in Table 1. Approximately 55% were female, 24% were 75-84 years of age, 57% White, and 78% of activations in urban areas.

As shown in Table 2, most EMS suspected stroke events had times within the defined EMS time intervals (73% for RT ≤8 minutes, 55% for OST ≤15 minutes). A greater proportion of females than males fell within the RT interval (RT: 74.1% vs. 71.8%, $p<0.001$), but not OST (54.3% vs. 56.0%, $p<0.0001$). Patients 85 years or older, Hispanics, and EMS activations in urban areas were more likely to meet the RT benchmark. Approximately 37% of stroke dispatch complaints were identified by EMS as a suspected stroke. Compared to those dispatched as “other”, events with a dispatch of stroke had a higher proportion of OST ≤15 minutes (57.4% versus 48.0%, $p<0.0001$), however they were less frequently transported to the hospital within 12 minutes (51.4% versus 55.0%, $p<0.0001$). BLS ambulances more frequently responded within the 8-minute interval (77.8% vs. 71.2% for ALS) and

transported to the hospital within 12 minutes (59.0% vs. 51.8% for ALS), however there was a small difference in on-scene time between the two (BLS: 51.1% vs. ALS: 54.2%).

Table 3 presents the mean and median prehospital time intervals by dispatch complaint. Median total prehospital time was slightly shorter for patients dispatched as stroke (35 minutes; IQR: 28, 46) than those dispatched as “other” (36 minutes; IQR: 28, 47). The longest time interval for both dispatch categories was OST. Events dispatched as stroke had a shorter OST (median 14; IQR: 11, 18) compared to those not dispatched as stroke (median 16; IQR: 12, 20).

In the adjusted analysis, events dispatched as stroke were more likely to meet the EMS time interval benchmarks for OST within 15 minutes (OST: ARR, 1.20; 95% CI [1.20-1.21]) (Table 4). However, they were less likely to be transported to the hospital within 12 minutes (TT: ARR, 0.94; 95% CI 0.94-0.95).

Discussion

In this study using national EMS data to examine EMS dispatch and prehospital time intervals for suspected stroke transports, only 37% were identified as stroke in the dispatch complaint. Those dispatched as stroke had a shorter OST (median 14 vs 16 minutes), and one-minute shorter total prehospital time (34 minutes vs 35 minutes) compared to those not dispatched as stroke. A significantly higher proportion of those dispatched as strokes met the recommended EMS prehospital time interval benchmark of OST ≤15 minutes. This association persisted after controlling for patient and EMS characteristics in our multivariate model. These results indicate that dispatch information may play an important role in EMS response times for time-sensitive conditions such as stroke.

The role of EMS is crucial in reducing the overall time from the onset of stroke symptoms to arrival at the ED, in order to initiate treatment within the critical time window. A previous study indicates that approximately one-third of potentially eligible patients do not receive IV alteplase treatment, even as rates of its use have significantly increased over the past decade (3). When the time window for IV alteplase treatment is missed, potential contributing factors include poor public awareness and recognition of stroke signs and symptoms, low rates of 911 system activation, and prehospital transport delays (8, 13).

As noted in the AHA/ASA recommendations for EMS systems, when integrated effectively within a stroke system, rapid EMS activation, response, and transport to an appropriate facility can translate into significant reductions in time for the treatment of a stroke patient (7, 9). Therefore, as the first line of contact for patients experiencing stroke symptoms, the assistance and identification of stroke by EMS dispatchers, even when not initially recognized by the public, is a critical step in prehospital care. Recognizing such symptoms and relaying vital information to the responding unit has been shown to cut down on the time EMS personnel use to gather information from patients and family members/bystanders at the scene (14, 15). In addition to reducing on-scene time, as it is the largest component of the prehospital time interval, quality improvement interventions have focused on activities to increase EMS dispatcher knowledge of stroke signs and symptoms (14,

15, 22). Several studies have demonstrated that such educational programs for both EMS dispatchers and ambulance personnel led to improved recognition of suspected strokes, faster patient assessment, and ultimately the administration of treatment (15). Therefore, it is important for EMS leaders to identify quality improvement interventions that effectively focus activities that ensure rapid initial assessment by dispatchers and rapid transport by reducing on-scene time, thereby potentially increasing the proportion of treatment eligible stroke patients. Programs such as the Paul Coverdell National Acute Stroke Program, funded by the Centers for Disease Control and Prevention, support quality improvement initiatives to improve care for stroke patients from the time EMS is notified through transition to the hospital ED that is most appropriate for the type of care required. Currently, nine funded state health departments engage in a variety of prehospital quality improvement efforts, including EMS education of stroke signs and symptoms, performance measures targeting on-scene time, and providing feedback to EMS regarding confirmed stroke calls and misses to support high quality stroke care.

Our results found that suspected stroke events with a dispatch of stroke have a slightly longer transport time, but shorter total prehospital time. Longer transport times may be due to the need to transport patients to a hospital destination that is most appropriate for stroke treatment and level of care needed (23). Generally, response time and transport time are less modifiable time intervals for EMS (8, 13). The time from scene to the hospital is also dependent on a variety of factors, such as traffic volume, or protocols on decisions for a destination. EMS agencies may have protocols that require the ambulance to transport suspected stroke patients to a certified stroke center, rather than the closest facility. Furthermore, drive-time to stroke centers vary across geographic settings. Our results were consistent with several drive-time analyses that demonstrate that drive-times are significantly longer for non-urban and suburban settings (24, 25).

The findings in our study are subject to several identified limitations. First, there are service level factors that we were not able to account for that may influence EMS response times. Results may not be generalizable to all EMS systems as there may be slight differences in EMS response times in factors such as type of EMS service (i.e. private, fire, hospital). Second, stroke events were identified using the EMS provider's impression and are not a confirmed hospital diagnosis. Third, NEMSIS is a registry of EMS activations (or events), therefore more than one record may exist for the same patient when multiple EMS agencies respond to the same event. It is difficult to identify multiple EMS events in the data for a single patient. Thus, our data may have overestimated the count of the stroke sample in our analysis. Additionally, as this study includes data from the previous version of NEMSIS, version 2, results presented here may not fully reflect recent system changes and programs targeted at improving the overall EMS response. Fourth, data completeness is a challenge in NEMSIS, and in our analysis, significant missingness that affected several study variables was not able to be rectified. Also, with the NEMSIS data source being the PCR, the race category is provider identified (as reported by the responding provider) and therefore may not accurately record the patient's identified race. Fifth, it is also important to note that with the large sample size of the data, results with small differences that were statistically significant but may not necessarily be clinically meaningful.

Conclusion

Improved outcomes after stroke onset are dependent on timely arrival to the hospital, thus it is important to support an efficient and rapid EMS response across the prehospital chain. In this study, suspected stroke patients were more likely to meet the recommended prehospital time intervals for OST when stroke was the complaint reported by dispatch, even after controlling for common patient demographics and EMS characteristics. However, approximately one in three EMS suspected stroke event were identified by dispatch. Our findings suggest that there is a notable opportunity to reduce prehospital delays by improving dispatcher recognition of stroke to rapidly prioritize 911 calls, minimize time spent on-scene, and potentially reduce total time to the hospital. Findings from this study may be used to prioritize strategies to improve prehospital delays by identifying gaps in dispatcher knowledge of stroke signs and symptoms and evaluate effective quality improvement interventions that support EMS use of protocols for timely transitions in the stroke system of care.

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Disclaimer:

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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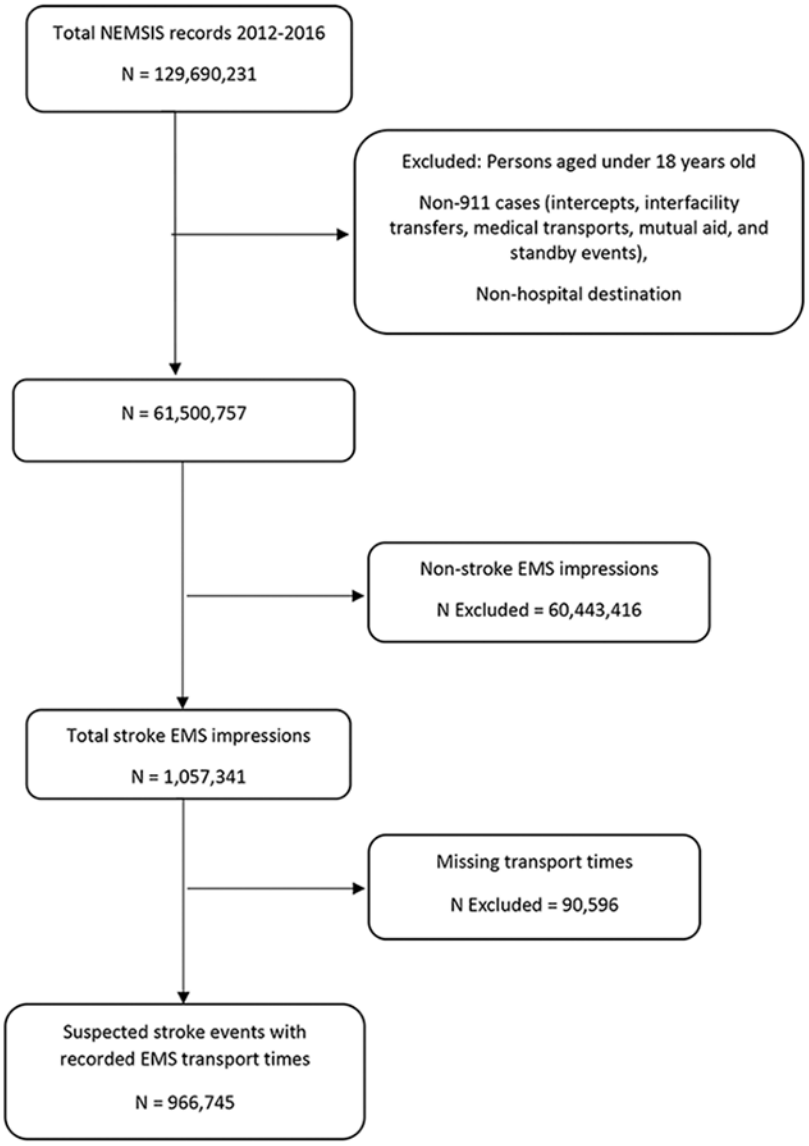

Figure 1.
Flow chart of selection of study population in NEMSIS 2012-2016 record.

Table 1:

Demographic Characteristics of 9-1-1 Activations with a Suspected Stroke (Primary or Secondary Stroke Impression) Transported by EMS to Hospital Destination– NEMSIS 2012-2016

Characteristics	Overall	
	911 Cases	Stroke Events N (%)
Total	61,500,757	1,057,341 (1.7)
Gender		
Female	33,267,566	582,815 (1.8)
Male	28,233,191	474,526 (1.7)
Age		
18-34	11,482,052	24,939 (0.2)
35-44	6,304,787	42,645 (0.7)
45-54	8,854,887	106,662 (1.2)
55-64	9,633,630	177,028 (1.8)
65-74	8,735,813	218,833 (2.5)
75-84	8,756,171	257,470 (2.9)
>85	7,733,417	229,764 (3.0)
Race		
Black or African American	10,823,657	151,889 (1.4)
Hispanics	2,583,809	28,495 (1.1)
White	31,895,422	631,801 (2.0)
Other	1,900,760	26,835 (1.4)
Missing	14,297,109	218,321 (1.5)
Urbanicity		
Urban	48,769,992	806,546 (1.7)
Suburban	4,647,049	85,571 (1.8)
Rural	5,122,046	103,941 (2.0)
Wilderness	1,365,590	30,244 (2.2)
Unknown	1,596,080	31,039 (1.9)
Dispatch Complaint		
Stroke	1,418,963	529,951 (37.4)
Other Condition	51,280,624	406,177 (0.8)
Level of Service		
BLS	11,147,380	76,133 (0.7)
ALS	23,696,477	476,062 (2.0)
Other	230,765	16,996 (7.4)
Missing	26,426,135	488,150 (1.9)

Abbreviation: EMS, Emergency medical services; BLS, Basic Life Support; ALS, Advanced Life Support.

Table 2:

Demographic Characteristics of 9-1-1 Activations with a Suspected Stroke (Primary or Secondary Stroke Impression) Transported by EMS to Hospital Destination, by Response Time, On-Scene Time, and Transport Time – NEMSIS 2012-2016

Characteristics	Response time (≤8 minutes)		On-scene time (≤15 minutes)		Transport time (≤12 minutes)	
	N (%)	P-value	N (%)	P-value	N (%)	P-value
Total	752,688 (73.1)	-	551,730 (53.4)	-	537,581 (52.8)	-
Gender		<.0001		<.0001		<.0001
Female	421,355 (74.2)		300,101 (52.7)		300,673 (53.6)	
Male	331,333 (71.8)		251,629 (54.2)		236,908 (51.9)	
Age		<.0001		<.0001		<.0001
18-34	17,801 (73.9)		15,218 (62.7)		13,285 (55.4)	
35-44	30,178 (73.1)		25,013 (60.1)		21,666 (52.7)	
45-54	74,882 (72.5)		60,936 (58.4)		54,469 (53.0)	
55-64	124,067 (72.2)		95,445 (55.1)		89,871 (52.7)	
65-74	150,998 (70.9)		112,583 (52.6)		105,609 (50.2)	
75-84	182,597 (72.7)		128,962 (51.2)		128,018 (51.7)	
>85	172,165 (76.6)		113,573 (50.6)		124,663 (56.4)	
Race		<.0001		<.0001		<.0001
Black or African American	110,633 (74.4)		74,861 (50.3)		89,377 (60.8)	
Hispanics	21,891 (78.7)		15,018 (53.6)		17,505 (63.6)	
White	437,217 (71.1)		332,240 (53.6)		300,499 (49.1)	
Other	20,061 (76.6)		14,580 (55.1)		15,708 (60.1)	
Missing	162,886 (76.9)		115,031 (54.7)		114,492 (55.9)	
Urbanicity		<.0001		<.0001		<.0001
Urban	588,889 (74.8)		421,436 (53.5)		426,453 (54.9)	
Suburban	56,829 (68.6)		42,259 (50.6)		38,983 (47.7)	
Rural	67,403 (67.2)		54,577 (53.3)		46,742 (46.3)	
Wilderness	18,200 (63.1)		15,981 (53.6)		11,069 (37.9)	
Unknown	21,367 (70.7)		17,477 (57.9)		14,334 (48.0)	

Characteristics	Response time (≤8 minutes)		On-scene time (≤15 minutes)		Transport time (≤12 minutes)	
	N (%)	P-value	N (%)	P-value	N (%)	P-value
Dispatch Complaint		<.0001		<.0001		<.0001
Stroke	379,547 (73.3)		297,213 (57.4)		262,273 (51.4)	
Other Condition	288,503 (73.2)		191,111 (48.0)		215,603 (55.0)	
Level of Service		<.0001		<.0001		<.0001
BLS	56,911 (77.8)		39,195 (53.5)		42,445 (59.0)	
ALS	331,468 (71.2)		247,614 (52.8)		240,509 (51.8)	
Other	3,718 (23.3)		9,742 (58.0)		2,334 (13.9)	
Missing	360,591 (75.9)		255,179 (53.7)		252,293 (54.3)	

Abbreviation: mins, minutes; EMS, Emergency medical services; BLS, Basic Life Support; ALS, Advanced Life Support.

Table 3:

Median and Interquartile Range (IQR)[†] of Prehospital Time Intervals by Dispatch Complaint Status for 9-1-1 Activations Transported by EMS to Hospital Destination – NEMSIS 2012-2016

	Overall			Dispatch Complaint: Stroke			Dispatch Complaint: Other		
	Mean	**Median**	**(Q1, Q3)**	**Mean**	**Median**	**(Q1, Q3)**	**Mean**	**Median**	**(Q1, Q3)**
Response time (RT)	7.4	6	(4,9)	7.3	6	(4, 9)	7.5	6	(4, 9)
On-scene time (OST)	16.9	15	(11,20)	16.1	14	(11, 19)	17.9	16	(12, 21)
Transport time (TT)	15.7	12	(7,19)	15.7	12	(7, 20)	15.7	11	(7, 19)
Total prehospital time [≠]	39.4	35	(27,45)	38.7	34	(27, 44)	40.3	35	(27, 46)

Abbreviations: EMS, Emergency Medical Services

[†]IQR: interquartile range reported in minutes as quartile 1 (25^{th}) and quartile 3 (75^{th})

[≠]Total transport prehospital time is sum of reported time intervals of response time, on-scene time, and transport time.

Table 4:

Adjusted Risk Ratios (ARR)[†] for Dispatch Report Independently Associated with EMS Time Intervals for Suspected Stroke Patients – NEMSIS 2012-2016

	Response time ≤8 minutes		On-Scene time ≤15 minutes		Transport time ≤12 minutes	
Complaint Reported by Dispatch	**ARR (95% CI)**	**P-Value**	**ARR (95% CI)**	**P-Value**	**ARR (95% CI)**	**P-Value**
Stroke	1.005 (1.002-1.007)	0.0002	1.204 (1.199-1.209)	<.0001	0.946 (0.943-0.950)	<.0001
Other Condition	Reference	NA	Reference	NA	Reference	NA

Abbreviations: EMS, Emergency Medical Services. RR, Risk Ratio. CI, Confidence Interval.

[†]Variables included in final multivariate model: age, gender, race, urbanicity, and EMS level of service