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Trends in intravenous thrombolysis utilization for acute ischemic stroke based on hospital size: Paul Coverdell National Acute Stroke Program, 2010–2019

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Abstract

Introduction: The rate of intravenous thrombolysis (IVT) utilization in acute ischemic stroke (AIS) has been increasing, and this has coincided with improved door-to-needle times (DNTs). Smaller hospitals have been observed to utilize IVT less frequently or even not at all. Using a multistate stroke registry, we sought to determine the impact of hospital size on trends in IVT utilization for AIS.

Methods: Utilizing data from the Paul Coverdell National Acute Stroke Program (PCNASP), we studied trends in IVT for AIS patients between 2010 and 2019 based on hospital size. Hospitals were grouped into quartiles based on size. We studied the impact of hospital size on DNTs and overall IVT utilization.

Results: During the study period, there were 530,828 AIS patients (mean age 70.3 ± 0.02 years, 50.4% men) from 540 participating hospitals. We did not identify a significant trend in IVT utilization among hospitals within the first quartile ($p = 0.1005$), but there were significantly increased trends within the hospitals belonging to the second, third, and fourth quartiles ($p < 0.001$ for all). All quartiles were observed to have significantly increased trends in DNTs ≤60 min ($p < 0.0001$), but only hospitals within the second, third, and fourth quartiles experienced significantly increased trends in DNTs ≤45 min ($p < 0.0001$).

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Declaration of Competing Interest

GA has nothing to disclose.

XT has nothing to disclose.

KL has nothing to disclose.

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.

Conclusion: In our registry-based analysis, we observed an increased trend in IVT utilization for AIS among larger hospitals. There was an overall improvement in rates of DNTs ≤60 min, but only larger hospitals were observed to have improved DNTs ≤45 min.

Keywords

Hospital size; Ischemic stroke; Thrombolysis; Trend analysis

1. Introduction

Stroke continues to be a leading cause of death and serious disability in the United States [1]. The rate of intravenous thrombolysis (IVT) utilization in acute ischemic stroke (AIS) has been increasing, and this has coincided with improved door-to-needle times (DNTs) [2,3]. Despite this observed trend, Kleindorfer and colleagues have discovered that more than half of the hospitals in the United States reported no use of IVT [4]. These tended to be smaller hospitals (average of approximately 95 beds) and those located in rural areas [4]. Small hospitals have been found to offer less optimal quality of stroke care, which has been correlated to lower IVT utilization rates; additionally, bed size has been reported to be inversely correlated with short-term mortality in some studies [5]. With overall increasing rates, we sought to determine the impact of hospital size on trends in IVT utilization for AIS using a multistate stroke registry.

2. Methods

Our study population included patients admitted with AIS from 2010 through 2019 within the Paul Coverdell National Acute Stroke Program (PCNASP). We only included patients with documented National Institutes of Health Stroke Scale Score (NIHSSS) at admission. The PCNASP is an ongoing acute stroke quality improvement program funded by the Centers for Disease Control and Prevention (CDC) and provides feedback to states on adherence to guidelines of care to improve care quality for patients hospitalized with stroke and transient ischemic attack (TIA). Within our study period, hospitals across twelve states (Arkansas, California, Georgia, Iowa, Massachusetts, Michigan, Minnesota, New York, North Carolina, Ohio, Washington, and Wisconsin) participated in PCNASP. Hospital participation within each state is voluntary, and trained abstractors from participating hospitals 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]. This study was approved by the CDC Institutional Review Board.

We defined the rates of IVT utilization as percent of AIS admissions. We identified the proportion of patients who received IVT within 60 min of arrival and within 45 min of arrival (DNT). Hospital size was defined by number of hospital beds at each participating site, and hospitals were divided into quartiles based on size. Baseline characteristics analyzed for the study included age, sex, and race/ethnicity. Clinical characteristics analyzed for the study included stroke severity upon presentation, as defined by NIHSSS, and proportion of patients arriving by ambulance. Comorbidities for patients studied included

history of prior stroke, hypertension, dyslipidemia, coronary artery disease, heart failure, diabetes, atrial fibrillation, and history of smoking.

Categorical variables were compared across groups using two-tailed Fisher's exact or chi-square tests. Descriptive statistics were expressed as means with standard error (SE), medians with interquartile range (IQR), and frequency (percentages). Continuous variables were compared using the Wilcoxon-Mann-Whitney rank test or the Kruskal-Wallis test. We examined trends and obtained the *p*-values based on Cochran-Armitage test. We performed both univariate and multivariate logistic regression analyses using generalized estimating equations (GEE) to assess the effects of hospital size on outcomes for stroke patients receiving IVT and present data as odds ratio (OR) and adjusted odds ratio (AOR) with confidence intervals (CI). Because patients were clustered within hospitals, the hospital was treated as a cluster variable in GEE models. All statistical analyses were performed using SAS software (version 9.4; SAS Institute, Cary, NC). The data that support findings within this study are available upon reasonable request to the corresponding author.

3. Results

From 2010 to 2019, we had available bed size information from 540 participating hospitals in PCNASP; the median hospital bed size was 237 (IQR 111, 404). Within these hospitals, there were 530,828 patients (mean age 70.3 ± 0.02 years, 50.4% men) with a clinical diagnosis of AIS presenting with documented NIHSS at admission. Hospitals belonging to the first quartile had <111 beds, second quartile had 111–236 beds, third quartile had 237–403 beds, and fourth quartile had ≥404 beds. Baseline and clinical characteristics are shown in Table 1. Among all patients identified through 2010–2019, approximately 46.2% of patients presented to participating hospitals by ambulance, median NIHSSS upon presentation was 4 (1, 9), and approximately 10.7% of patients received IVT. Among all studied patients approximately 6.3% had DNTs ≤60 min, and approximately 3.7% had DNTs ≤45 min.

We identified significantly increased trends in the utilization of IVT within the hospitals belonging to the second, third, and fourth quartiles (Table 2, $p < 0.001$ for all). Hospitals in the second quartile increased IVT utilization from 8.9% of patients in 2010 to 10.4% of patients in 2019. Hospitals in the third quartile increased IVT utilization from 9% of patients in 2010 to 11.2% of patients in 2019. Hospitals in the fourth quartile increased IVT utilization from 10.7% of patients in 2010 to 11.9% of patients in 2019. These increases in IVT utilization corresponded to significantly increased trends in DNTs ≤60 min and ≤ 45 min (Figs. 1 and 2) in hospitals within the second, third, and fourth quartiles as well ($p < 0.001$ for all). While there was no significantly increased trend for IVT utilization among hospitals within the first quartile ($p = 0.1005$), these hospitals did experience a significantly increased trend in DNTs ≤60 min from 1.1% of patients in 2010 to 4.1% of patients in 2019 ($p < 0.001$). The proportion of patients with DNT ≤45 min at hospitals within the first quartile was too small to identify a trend.

Patients receiving IVT were less likely to have presented to hospitals in the first (AOR 0.53 [95% CI 0.49–0.57]), second (AOR 0.83 [95% CI 0.81–0.85]), and third (AOR 0.91

[95% CI 0.89–0.93]) quartiles when compared to hospitals belonging to the fourth quartile. This corresponded to lower likelihood of DNT ≤60 min among patients who presented to hospitals in the first (AOR 0.34 [95% CI 0.30–0.38]), second (AOR 0.65 [95% CI 0.63–0.68]), and third (AOR 0.76 [95% CI 0.74–0.78]) quartiles (Table 3). Similarly, patients with DNT ≤45 min were less likely to have presented to hospitals in the first (AOR 0.24 [95% CI 0.21–0.28]), second (AOR 0.57 [95% CI 0.55–0.60]), and third (AOR 0.66 [95% CI 0.64–0.69]) quartiles (Table 3).

4. Discussion

Over the past two decades, ongoing intervention programs have focused on providing all patients with sufficient access to time-sensitive reperfusion treatment options for AIS [8,9]. Extensive work with communities, including mass media strategies have shown the potential in helping increase acute stroke treatments [9]. The wider implementation of telestroke services has also helped increase access to care [8]. In 2011, approximately 20% of Americans lacked timely access to IVT-capable hospitals; however, with increase in hospital seeking stroke quality care certification, approximately 96% of the United States population are within 60 min of an emergency department with any acute stroke capabilities [8]. Even further, 99% of Americans have access to hospitals within 120 min for either IVT or endovascular therapy by ground or air ambulance [10].

In 2013, the Brain Attack Coalition endorsed the establishment of a certification program for acute stroke ready hospitals (ASRH) [11]. ASRHs are typically hospitals with fewer than 100 beds and can be found in suburban or rural locations [12]. By establishing performance metrics for ASRHs, these centers can form the base of any regional stroke system of care [11]. Alberts and colleagues suggested that the development of an ASRH network could increase the chances of AIS patients receiving timely interventions and higher chances of favorable outcomes [11]. Tsai and colleagues evaluated Minnesota-based data and discovered that early adoption of ASRH status led to a significantly increased trend in IVT utilization for AIS; however, this trend was not observed among hospitals that never achieved ASRH status [13].

With improving access to care, we know that rates of IVT utilization are increasing concurrently with improved DNTs [2,3]. Hospital size has been shown to be an important predictor of quality of care for stroke patients [5]; therefore, we elected to study the impact of hospital size on rates of IVT utilization as well as timeliness of treatment. Our results show that hospitals within the second, third, and fourth quartiles experienced significantly increased trends in IVT utilization rates from 2010 to 2019. Timeliness to treatment also significantly increased within these quartiles with increased rates of DNTs ≤60 min and ≤ 45 min. Smaller hospitals belonging to the first quartile did not experience a significant trend in IVT utilization rates during the study period, but a significantly increased trend in DNTs ≤60 min was observed. There was no improvement in rates of DNTs ≤45 min among first quartile hospitals. Previous analyses suggest that achieving optimal DNTs are likely secondary to varying levels of infrastructure and resources required for acute stroke care [3], which confirms why we identified that larger hospitals likely achieved better DNTs.

Additionally, stroke centers with at least 100 stroke cases per year were found to have greater annual decreases in DNTs [3].

Important strengths of our study include the large number of patients from a multi-state registry during regular care delivery. The voluntary nature of the PCNASP limits generalizability, and hospitals more oriented toward quality improvement may be more likely to participate in the registry. Some participating hospitals who did not have quality improvement resources may not have participated in some years. Therefore, the trends we observed with PCNASP data may not be indicative of overall national trends and should be interpreted with caution.

5. Conclusion

We observed an increased trend in IVT utilization for AIS among larger hospitals participating in PCNASP. Hospitals of all sizes in PCNASP were noted to have improved rates of DNTs ≤60 min, but only larger hospitals improved in rates of DNTs ≤45 min. Ongoing quality improvement efforts should focus on smaller hospitals to continue increasing rates of IVT utilization for AIS.

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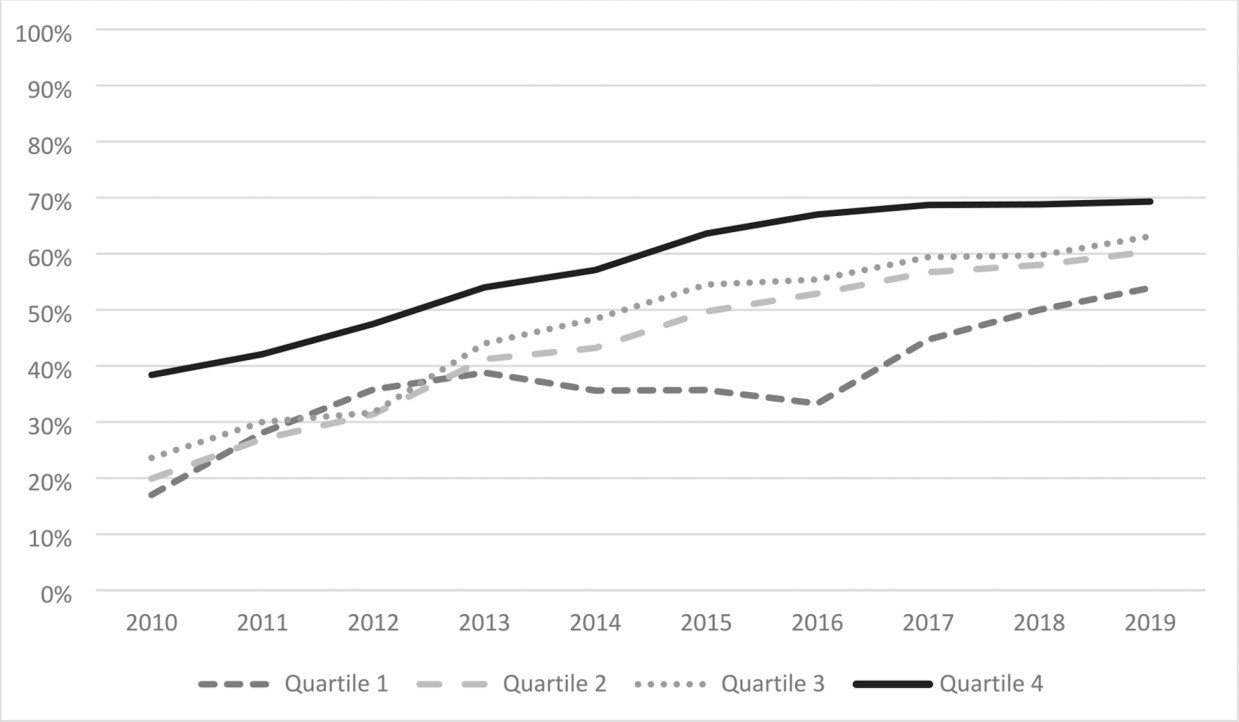

Fig. 1.

Door to needle times within 60 minutes among patients receiving intravenous thrombolysis based on hospital size, 2010–2019.

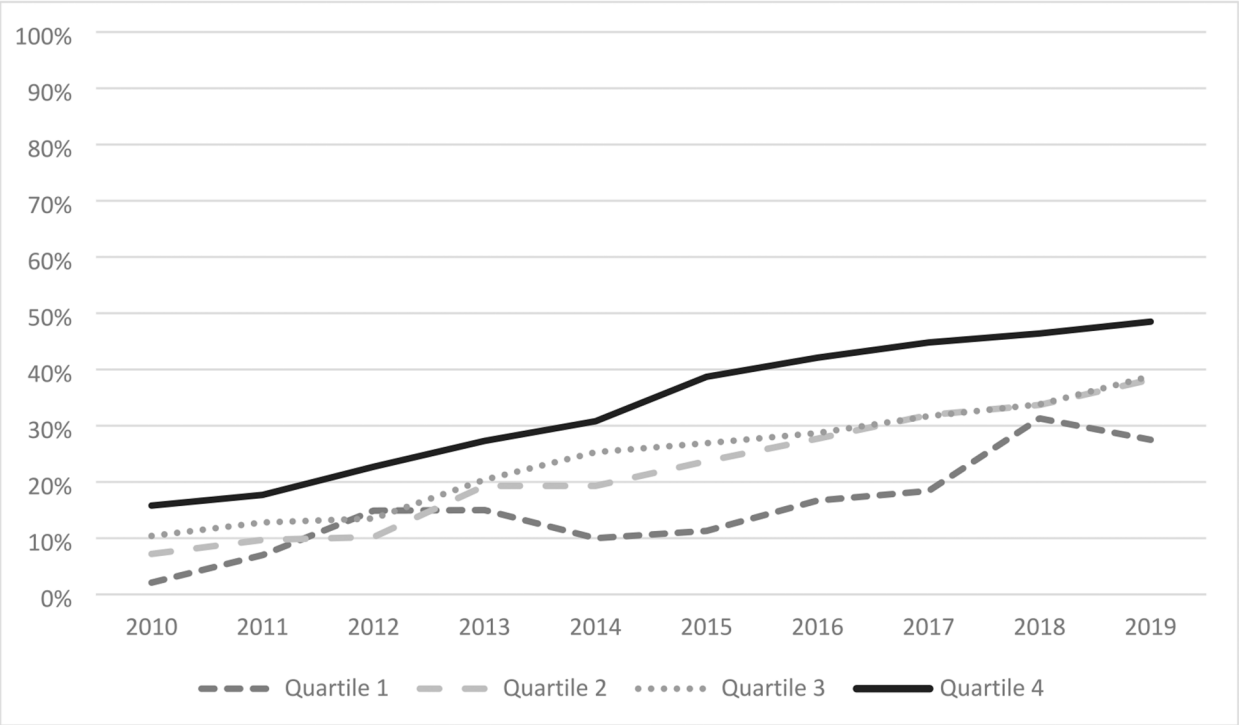

Fig. 2.

Door to needle times within 45 minutes among patients receiving intravenous thrombolysis based on hospital size, 2010–2019.

Table 1

Baseline and Clinical Characteristics of Acute Ischemic Stroke Admissions by Hospital Bed Size, 2010–2019.

Variables	Overall n (%) or statistics (*N* = 530,828)	1st quartile (<111 beds) (*n* = 15,452)	2nd quartile (111–236 beds) (*n* = 81,474)	3rd quartile (237–403 beds) (*n* = 130,236)	4th quartile (≥404 beds) (*n* = 303,666)
Mean age (SE), years	70.3 (0.02)	72.8 (0.11)	71.5 (0.05)	71.5 (0.04)	69.4 (0.03)
No. of males (%)	267,420 (50.4)	7270 (47.0)	39,848 (48.9)	64,457 (49.5)	155,845 (51.3)
Race/Ethnicity					
Non-Hispanic White	383,397 (72.2)	12,853 (83.2)	62,953 (77.3)	99,400 (76.3)	208,191 (68.6)
Non-Hispanic Black	94,604 (17.8)	1771 (11.5)	11,477 (14.1)	19,797 (15.2)	61,559 (20.3)
Hispanic	17,775 (3.3)	269 (1.7)	2374 (2.9)	4284 (3.3)	10,848 (3.6)
Arrival by ambulance	245,018 (46.2)	7096 (45.9)	40,256 (49.4)	63,793 (49.0)	133,873 (44.1)
Median NIHSSS (IQR)	4 (1, 9)	3 (1,7)	3 (1,7)	3 (1, 8)	4 (1,10)
Received IVT (%)	56,888 (10.7)	946 (6.1)	7741 (9.5)	13,618 (10.5)	34,583 (11.4)
DNT ≤ 60 min (%)	33,275 (6.3)	382 (2.5)	3929 (4.8)	7338 (5.6)	21,626 (7.1)
DNT ≤ 45 min (%)	19,644 (3.7)	167 (1.1)	2124 (2.6)	3961 (3.0)	13,392 (4.4)
Medical history (%)					
Prior stroke	132,463 (25.0)	3945 (25.5)	20,157 (24.7)	33,696 (25.9)	74,665 (24.6)
Hypertension	403,316 (76.0)	11,906 (77.1)	62,643 (76.9)	100,680 (77.3)	228,087 (75.1)
Dyslipidemia	260,317 (49.0)	7789 (50.4)	41,316 (50.7)	67,504 (51.8)	143,708 (47.3)
CAD	127,526 (24.0)	3769 (24.4)	19,403 (23.8)	32,723 (25.1)	71,631 (23.6)
Heart failure	54,580 (10.3)	1537 (9.9)	7677 (9.4)	13,551 (10.4)	31,815 (10.5)
Diabetes	177,356 (33.4)	5154 (33.4)	27,839 (34.2)	44,510 (34.2)	99,853 (32.9)
Atrial fibrillation	102,528 (19.3)	3087 (20.0)	15,566 (19.1)	25,832 (19.8)	58,043 (19.1)
History of smoking	104,707 (19.7)	2804 (18.1)	14,887 (18.3)	24,460 (18.8)	62,556 (20.6)
Trends in Hospital Admissions of Acute Ischemic Stroke Patients Across all Four Quartiles (%)					
Percentages in each quartile reflect the proportion of admissions by year					
2010	19,391 (3.7)	749 (3.9)	2653 (13.7)	4278 (22.1)	11,711 (60.4)
2011	23,931 (4.5)	1112 (4.6)	3113 (13.0)	5428 (22.7)	14,278 (59.7)
2012	27,466 (5.2)	1180 (4.3)	4063 (14.8)	6026 (21.9)	16,197 (59.0)
2013	43,370 (8.2)	1403 (3.2)	6687 (15.4)	9871 (22.8)	25,409 (58.6)
2014	53,895 (10.2)	1553 (2.9)	8437 (15.7)	13,090 (24.3)	30,815 (57.2)
2015	57,131 (10.8)	1564 (2.7)	8793 (15.4)	14,103 (24.7)	32,671 (57.2)

Variables	Overall n (%) or statistics (*N* = 530,828)	1st quartile (<111 beds) (*n* = 15,452)	2nd quartile (111–236 beds) (*n* = 81,474)	3rd quartile (237–403 beds) (*n* = 130,236)	4th quartile (≥404 beds) (*n* = 303,666)
2016	62,730 (11.8)	1590 (2.5)	9798 (15.6)	15,988 (25.5)	35,354 (56.4)
2017	72,869 (13.7)	1932 (2.7)	10,962 (15.0)	18,479 (25.4)	41,496 (56.9)
2018	81,453 (15.3)	2053 (2.5)	13,052 (16.0)	20,757 (25.5)	45,591 (56.0)
2019	88,592 (16.7)	2316 (2.6)	13,916 (15.7)	22,216 (25.1)	50,144 (56.6)

Abbreviations: CAD = coronary artery disease; DNT = door to needle time; IQR = interquartile range; IVT = intravenous thrombolysis; NIHSSS=National Institutes of Health Stroke Scale score; SE = standard error.

Table 2

Trends in IVT utilization by year based on hospital size, 2010–2019.

		2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	P for trend
1st quartile (<111 beds)	No. of patients	749	1112	1180	1403	1553	1564	1590	1932	2053	2316	
	Received IVT N(%)	47 (6.3)	57 (5.1)	67 (5.7)	80 (5.7)	90 (5.8)	115 (7.4)	96 (6.0)	114 (5.9)	102 (5.0)	178 (7.7)	0.1005
	DNT ≤60 min N(%)	8 (1.1)	16 (1.4)	24 (2.0)	31 (2.2)	32 (2.1)	41 (2.6)	32 (2.0)	51 (2.6)	51 (2.5)	96 (4.1)	<0.001
	DNT ≤45 min N(%)	1 (0.1)	4 (0.4)	10 (0.8)	12 (0.9)	9 (0.6)	13 (0.8)	16 (1.0)	21 (1.1)	32 (1.6)	49 (2.1)	NA
2nd quartile (111–236 beds)	No. of patients	2653	3113	4063	6687	8437	8793	9798	10,962	13,052	13,916	
	Received IVT N(%)	236 (8.9)	259 (8.3)	344 (8.5)	616 (9.2)	727 (8.6)	735 (8.4)	950 (9.7)	1065 (9.7)	1368 (10.5)	1441 (10.4)	<0.001
	DNT ≤60 min N(%)	47 (1.8)	70 (2.2)	108 (2.7)	254 (3.8)	314 (3.7)	365 (4.2)	503 (5.1)	604 (5.5)	793 (6.1)	871 (6.3)	<0.001
	DNT ≤45 min N(%)	17 (0.6)	25 (0.8)	35 (0.9)	119 (1.8)	140 (1.7)	174 (2.0)	263 (2.7)	340 (3.1)	461 (3.5)	550 (4.0)	<0.001
3rd quartile (237–403 beds)	No. of patients	4278	5428	6026	9871	13,090	14,103	15,988	18,479	20,757	22,216	
	Received IVT N(%)	385 (9.0)	437 (8.1)	526 (8.7)	1014 (10.3)	1334 (10.2)	1451 (10.3)	1748 (10.9)	1893 (10.2)	2331 (11.2)	2499 (11.2)	<0.001
	DNT ≤60 min N(%)	91 (2.1)	131 (2.4)	167 (2.8)	447 (4.5)	646 (4.9)	791 (5.6)	969 (6.1)	1125 (6.1)	1393 (6.7)	1578 (7.1)	<0.001
	DNT ≤45 min	40 (0.9)	56 (1.0)	71 (1.2)	207 (2.1)	337 (2.6)	391 (2.8)	502 (3.1)	601 (3.3)	787 (3.8)	969 (4.4)	<0.001
4th quartile (≥404 beds)	No. of patients	11,711	14,278	16,197	25,409	30,815	32,671	35,354	41,496	45,591	50,144	
	Received IVT N(%)	1250 (10.7)	1471 (10.3)	1742 (10.8)	2802 (11.0)	3235 (10.5)	3476 (10.6)	4037 (11.4)	5066 (12.2)	5522 (12.1)	5982 (11.9)	<0.001
	DNT ≤60 min N(%)	480 (4.1)	619 (4.3)	827 (5.1)	1513 (6.0)	1846 (6.0)	2209 (6.8)	2704 (7.6)	3483 (8.4)	3801 (8.3)	4144 (8.3)	<0.001
	DNT ≤45 min N(%)	198 (1.7)	261 (1.8)	395 (2.4)	764 (3.0)	996 (3.2)	1346 (4.1)	1698 (4.8)	2268 (5.5)	2563 (5.6)	2903 (5.8)	<0.001

Abbreviations: DNT = door to needle times; IVT = intravenous thrombolysis.

Table 3

Effect of hospital size on IVT utilization and time to treatment, 2010–2019.

		OR (95% CI)	AOR (95% CI)
Received IVT	1st quartile	0.51 (0.47–0.54)	0.53 (0.49–0.57)
	2nd quartile	0.82 (0.80–0.84)	0.83 (0.81–0.85)
	3rd quartile	0.91 (0.89–0.93)	0.91 (0.89–0.93)
	4th quartile	Ref	Ref
DNT ≤60 min	1st quartile	0.33 (0.30–0.37)	0.34 (0.30–0.38)
	2nd quartile	0.66 (0.64–0.68)	0.65 (0.63–0.68)
	3rd quartile	0.78 (0.76–0.8)	0.76 (0.74–0.78)
	4th quartile	Ref	Ref
DNT ≤45 min	1st quartile	0.24 (0.20–0.28)	0.24 (0.21–0.28)
	2nd quartile	0.58 (0.55–0.61)	0.57 (0.55–0.6)
	3rd quartile	0.68 (0.66–0.7)	0.66 (0.64–0.69)
	4th quartile	Ref	Ref

Abbreviations: AOR = adjusted odds ratio; CI = confidence interval; DNT = door to needle time; IVT = intravenous thrombolysis; OR = odds ratio.

*Adjusted for age, sex, race/ethnicity, arrival by ambulance, National Institutes of Health Stroke Scale score.