Variability and Delay in Telestroke Physician Alert among Spokes in a Telestroke Network: A Need for Metric Benchmarks

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Introduction: Telestroke has increased access to acute management of ischemic stroke in areas that lack stroke care expertise, yet delays persist in evaluation and treatment. We describe variation in time to alert a telestroke physician of suspected acute ischemic stroke patients potentially eligible for acute stroke therapies among community hospitals in our telestroke network, and explore demographic and spoke-related characteristics associated with delays. *Methods:* From our telestroke registry, we identified suspected acute ischemic stroke patients who arrived within 6 hours of symptom onset and underwent video consultation at 1 of 17 community hospitals in our hub-and-spoke network. We compared time between patient arrival to telestroke alert (door-to-page-time) and to tissue plasminogen activator (tPA) administration for eligible patients (door-to-needle-time). We identified factors associated with prolonged metrics. *Results:* Of 1020 cases between 9/2015 and 3/2017, 47% received tPA. Sixty percent had door-to-page-time more than 15 minutes (median 19.5; IQR, 11-34). Door-to-page-time more than 15 minutes was associated with an 8-fold increase in likelihood of door-to-needle-time more than 60 minutes. Patients with severe stroke experienced faster door-to-page-times. Hospitals with more beds had prolonged door-to-page-time. Full time in-house neurology presence, even when not covering emergent consultations, was associated with faster door-to-page-time over telestroke. Seventy-one percent of patients underwent CT brain prior to the telestroke physician alert; this scenario delayed door-to-page and door-to-needle times. *Conclusions:* Door-to-page-time varied considerably among spokes. Awaiting CT scan prior to alerting the telestroke consultant of a stroke code delayed metrics. Telestroke physician alert standards are needed, as are educational initiatives on acute ischemic stroke management and workflow.

Key Words: Telemedicine—telestroke—ischemic stroke—acute stroke care—healthcare delivery systems—metrics

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Introduction

Telestroke (TS) is a safe, reliable, and effective approach for the evaluation and treatment of acute ischemic stroke (AIS) in areas underserved by stroke neurologists.[1-2] TS has increased tissue plasminogen activator (tPA) use and broadened access to stroke expertise.[1-4] However, delays have been reported in AIS management and treatment metrics in several TS networks.[5-7] Benchmarks for acute stroke care in the emergency room (ER)[8] and standards for TS management of AIS have been established,[4] yet similarly standardized time metrics for AIS workflow at community hospitals for TS activation and TS care are not yet defined. In the largest report of its kind of over 1000 TS consultations for suspected AIS patients, we illustrate the variability in the time a community hospital takes to activate a telemedicine consult among 17 spokes in our hub-and-spoke network. Furthermore, we explore demographic and spoke-specific factors associated with prolonged times to TS activation.

Methods

Our TS hub, which is part of an academic Neurology department, provides remote consultative services to 17 different spokes in surrounding communities. Distance from spoke to hub varies from approximately 4 to 200 miles. Spokes vary in number of beds, stroke center certification level, availability and amount of neurology coverage, and number of years in our TS network. Spokes have either no, partial, or full in-house neurology coverage. For spokes with full in-house neurology coverage, TS consultation assists in scenarios when the neurologists covering inpatient consults cannot feasibly respond to emergent strokes consultations in the ER at the same time. Our hub provides spokes with 24/7 remote and urgent neurology coverage via 2-way audiovisual consultation by a neurology-trained physician.

TS code strokes are alerted at the discretion of the spoke hospital staff and are initiated either by triage staff, nursing personnel, or a physician within a given spoke. Spoke sites undergo initial and recurrent training from the hub encouraging early involvement of the TS consultation as soon as a patient is identified with signs of AIS. Once a potential AIS patient is identified, the spoke site staff contacts the telemedicine call center, which then pages the TS physician on call. TS physicians are expected to call back within 10 minutes from the alert to obtain information on the patient. The TS physician will review imaging and records, and start the video consultation in the most efficient order they see fit at the time. Timing of CT scan completion in relation to when the TS stroke alert is paged is managed by the spoke, however spokes do not await a formal radiology read prior to requesting an urgent TS consultation. At the time of this study, there were no formal protocols regarding transporting patients directly to CT scan upon arrival. For tPA candidates, once the decision has been made to administer tPA, the TS physician usually stays on the camera to assist with dosing, consent, and otherwise as needed until the infusion is started.

From our TS stroke registry,[9] we identified patients who arrived to the ED with symptoms suggestive of AIS and subsequently evaluated by video consultation at 1 of 17 spokes from 9/2015 to 3/2017. About 3510 consecutive patients who underwent video consultation were screened in the registry. Of these, 2490 were excluded from the analysis (1964 had a diagnosis other than ischemic stroke including intracranial hemorrhage, 160 were inpatient code stroke activations, 366 presented either more than 6 hours from symptom onset or with unknown last known time). Patients who were evaluated via telephone consultation were excluded. Patients for which the arrival time or, when applicable, tPA administration times were unavailable were also excluded.

Metrics compared among spokes included the time from when the patient arrived to the spoke ER to the TS code stroke was paged out to the TS physician on call, or door-to-page-time (DTPT), and the time from patient arrival to the ER to tPA administration, or door-to-needle-time (DTNT). Arrival time was recorded by the spoke, page time tracked through the call center, CT scan time-stamped by the spoke, and tPA administration time documented by the TS physician and confirmed with the spoke sites. For applicable AIS metrics, we used the American Heart Association/American Stroke Association's Target: Stroke initiative recommended goal timing for comparison.[8] A code book guides our TS registry research team on abstracting data from these sources, with routine data quality checks.

We compared metrics among patient-level and clinical characteristics including age, gender, race and ethnicity, and stroke severity. Mild severity stroke was defined as National Institutes of Health Stroke Scale less than or equal to 5. We compared metrics among spoke factors including the number of years in the TS network, average number of AIS consults per month, number of beds, degree of in-house neurology coverage, presence of an Emergency Medical Services prenotification protocol, and location in a medical underserved area (MUA) as designated by the Health Resources and Services Administration (https://data.hrsa.gov/tools/shortage-area/mua-find) at the time of data analysis. We compared DTPT and DTNT based on whether CT scan was performed prior to the TM physician alert. We adjusted for baseline patient characteristics including age, gender, race and ethnicity, and stroke severity. Continuous variables were statistically compared using Kruskal-Wallis test, and categorical variables were compared with logistic regression.

IRB approval was obtained for this study.

Results

Baseline Patient Characteristics

Of the 1020 patients included, median age was 65 (IQR, 54-78) (Table 2). Fifty-one percent were female. Fifty-eight

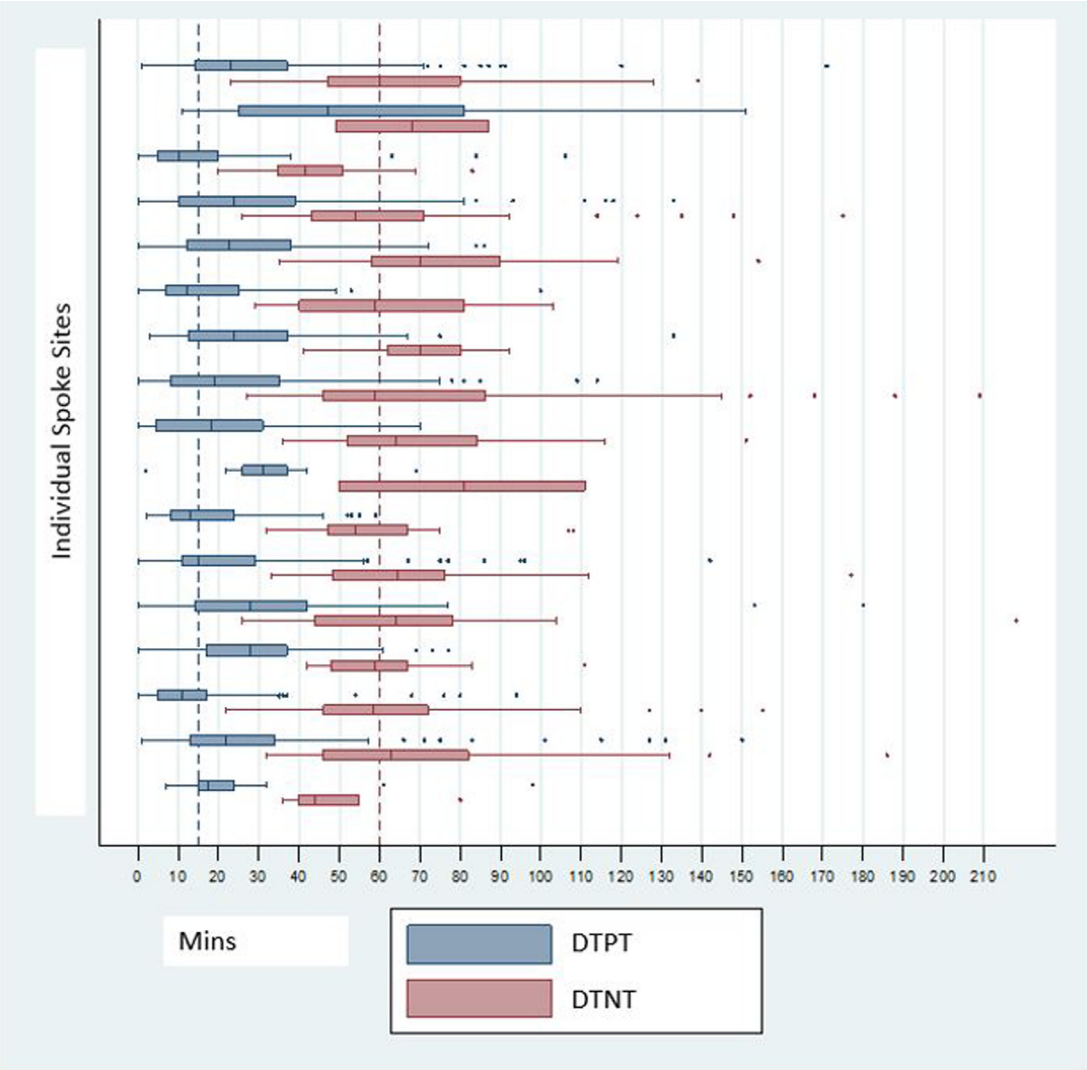

Figure 1. *DTPT and DTNT (minutes) variability among spokes. DTPT of more than 3 hours were excluded from the graph (3 patients total). Dotted vertical lines represent American Heart Association/American Stroke Association standard code stroke metrics.*[8] *Abbreviations: DTNT, door-to-needle-time; DTPT, door-to-page-time.*

percent were patients of non-Hispanic white, 23% of non-Hispanic black, and 16% of Hispanic race and ethnicity. Median NIHSS was 5 (IQR, 2-9), with 54% of patients presenting with NIHSS less than or equal to 5.

Of the 478 patients who received tPA, median age was 63 (IQR, 52-77) (Table 5). Fifty percent were female. Fifty-eight percent of the patients were of non-Hispanic white, 23% of non-Hispanic black, and 16% of Hispanic race and ethnicity. Median NIHSS was 7 (IQR, 4-15), with 35% of patients presenting with NIHSS less than or equal to 5.

Alerting the Telestroke Physician

There was a wide range in DTPT among spokes for 1020 patients seen via TS for AIS (Fig 1). Median DTPT was 19.5 minutes (IQR, 11-34); 40% had DTPT less than or equal to 15 minutes and 24% more than 35 minutes (Table 1). There were no differences in baseline demographics, including age, gender, and race and ethnicity, among patients who had DTPT of less than or equal to 15 minutes and more than 15 minutes; however, patients presenting with more severe stroke symptoms were less likely to have delayed DTPT (Table 2). Spoke characteristics that were evaluated are listed in Table 3. DTPT did not depend on the number of years spoke hospitals were in the TS network, the number of TS consults per month the spoke managed, whether or not the spoke was located in a MUA, nor the presence of an ER prenotification protocol (Table 4). Larger spoke hospitals were more likely to have delayed DTPT. However, the presence of full-time in-house Neurology coverage was associated with DTPT less than or equal to 15 minutes. Patients for whom a TS

Table 1. *Telemedicine code stroke metrics*

Door-to-page-time (n = 1020) 19.5 (11, 34)		Door-to-needle-time (n = 478) 59 (47, 79)	
Mins	n (%)	Mins	n (%)
≤15	411 (40)	≤45	112 (23)
≤20	119 (52)	≤60	139 (53)
≤25	120 (64)	≤75	95 (72)
≤30	65 (70)	≤90	59 (9)
≤35	61 (76)	≤105	27 (90)
>35	244 (24)	>105	46 (10)

page occurred after the CT scan was performed were more likely to have delayed DTPT (Table 4).

tPA Administration at the Spoke

Of the 1020 patients who presented to a spoke, 47% received tPA. There was a wide range in DTNT (Fig 1). Median DTNT was 59 minutes (IQR, 47-79), with 53% of patients meeting the accepted DTNT standard of 60 minutes in this data set (Table 1). Female patients were more likely to receive tPA after 60 minutes as compared to male patients (Table 5). Otherwise, there were no differences in whether DTNT met goal metrics among age, race and ethnicity, and stroke severity. There were no differences among spoke characteristics in receiving tPA within 60 minutes (Table 6). However, patients who had DTPT more than 15 minutes were less likely to receive tPA than patients with DTPT less than or equal to 15 minutes (OR .57, 95% CI .44-.73). Delayed DTPT was associated with a DTNT more than 60 minutes, as was alerting the TS physician after obtaining CT brain (Table 6).

In 71% of cases, CT scan was performed prior to TS alert. Median time between patient arrival and CT scan was 10 minutes. Eighty-five percent of patients had CT brain completed within 25 minutes.

Table 3. *Spoke characteristics*

Average no. of telestroke consults
≤10/Month (7/17 spokes)
>10/Month (10/17 spokes)
No. of beds in spoke hospital
≤300 Beds (11/17 spokes)
>300 Beds (6/17 spokes)
In-house neurology coverage
None or part time (9/17 spokes)
Full time (8/17 spokes)
Prenotification protocol
No (15/17 spokes)
Yes (2/17 spokes)
Medically underserved area
No (11/17 spokes)
Yes (6/17 spokes)

Discussion

Performance metrics for TS consultations are heavily dependent on the time that the TS consultant is alerted of the patient in the spoke emergency department.[2] Several TS networks that treat AIS attribute prolonged treatment metrics to a prolonged time to TS consultant alert.[5-6] We found a wide range in DTPT among spokes in our TS network. Per guidelines for in-person AIS evaluation, during a code stroke the Stroke Team notification should occur within 15 minutes of arrival,[8] yet less than half of suspected AIS cases met this metric in our study population of patients evaluated via TS. We found that a DTPT of more than 15 minutes was associated with prolonged DTNT. While DTNT did not differ among spoke

Table 2. *Door-to-page-time variability among patient characteristics*

	Total n = 1020	≤15 min n = 411	>15 min n = 609	OR (CI)[†]
Age, median (q1, q3)	65 (54, 78)	64 (54, 78)	65 (53, 78)	
≤70 years old, n (%)	632 (62.0)	255 (62.0)	377 (61.9)	Ref
>70 years old, n (%)	388 (38.0)	156 (38.0)	232 (38.1)	1.01 (.78-1.30)
Gender, n (%)				
Male	496 (48.6)	203 (49.4)	293 (48.1)	Ref
Female	524 (51.4)	208 (50.6)	316 (51.9)	1.05 (.82-1.35)
Race/Ethnicity, n (%)				
Non-Hispanic White	594 (58.2)	236 (57.4)	358 (58.8)	Ref
Non-Hispanic Black	237 (23.2)	95 (23.1)	142 (23.3)	.99 (.72-1.34)
Hispanic	164 (16.1)	66 (16.1)	98 (16.1)	.98 (.69-1.39)
NIHSS, n (%)				
≤5	554 (54.3)	198 (48.2)	356 (58.5)	Ref
>5	444 (43.5)	205 (49.9)	239 (39.2)	.65 (.50-.84)

Abbreviations: NIHSS, National Institutes of Health Stroke Scale.
[†]For quantitative variables Kruskal-Wallis test are used to assess the differences between 2 groups. For categorical variables Logistic Regression are employed for statistical comparison.

Table 4. *Door-to-page-time variability among spoke characteristics and code stroke workflow*

	Total n = 1020	≤15 min n = 411	>15 min n = 609	OR (CI)[†]	Adjusted OR (CI)[‡]
Years in TS Network, n (%)					
≤3 Years	443 (43.4)	164 (39.9)	279 (45.8)	Ref	Ref
>3 Years	577 (56.6)	247 (60.1)	330 (54.2)	.79 (.61-1.01)	.79 (.60-1.03)
Average no. of consults, n (%)					
≤ 10/mo	220 (21.6)	96 (23.34)	124 (20.4)	Ref	Ref
>10/mo	800 (78.4)	315 (76.6)	485 (79.6)	1.19 (.88-1.61)	1.24 (.91-1.69)
No. of beds at spoke, n (%)					
≤300 beds	498 (48.8)	220 (53.5)	278 (45.7)	Ref	Ref
>300 beds	522 (51.2)	191 (46.5)	331 (54.4)	1.37 (1.07-1.76)	1.43 (1.11-1.85)
In-house neuro coverage, n (%)					
None or part time	549 (53.8)	202 (49.2)	347 (57.0)	Ref	Ref
Full time	471 (46.2)	209 (50.9)	262 (43.0)	.73 (.57-.94)	.72 (.56-.94)
Prenotification protocol, n (%)					
No	848 (83.1)	330 (80.3)	518 (85.1)	Ref	Ref
Yes	172 (16.9)	81 (19.7)	91 (14.9)	.72 (.51-1.00)	.73 (.52-1.02)
Medically underserved, n (%)					
No	697 (68.3)	290 (70.6)	407 (66.8)	Ref	Ref
Yes	323 (31.7)	121 (29.4)	202 (33.2)	1.19 (.91-1.56)	1.23 (.93-1.62)
TS Page after CT scan, n (%)					
No	300 (29.4)	207 (50.4)	93 (15.3)	Ref	Ref
Yes	720 (70.6)	204 (49.6)	516 (84.7)	5.63 (4.20-7.55)	6.28 (4.61-8.56)

Abbreviations: TS, Telestroke.
[†]For categorical variables *Logistic Regression* were employed for statistical comparison.
[‡]Adjusted for age, gender, race/ethnicity, initial National Institutes of Health Stroke Scale.

characteristics in the same manner as DTPT, only about half of cases met the expected 60-minute goal. Efforts therefore to improve DTPT could lead to improved tPA administration and reperfusion times.

In an initial review of metrics from 2008 to 2011 of 231 patients at the Medical University of South Carolina's TS network, prolonged DTNT was attributed to a delay between patient ED arrival and the time a TS consult was requested.[5] Their median time from arrival to TS consultation alert was a median of 33 minutes (range 2-273, IQR not reported), and in this patient population they found a median DTNT of 87 minutes (range 26-290, IQR not reported). In this code stroke activation protocol, patients underwent initial ED evaluation and triage, and then were registered simultaneously with the CT scan, and subsequently the TS consultation was requested.[5] A TS

Table 5. *Door-to-needle-time variability among patient characteristics*

	Total n = 478	≤60 min n = 251	>60 min n = 227	OR (CI)[†]
Age, median (q1, q3)	63 (52, 77)	62 (52, 75)	64 (53, 80)	
≤70 years old, n (%)	305 (63.81)	166 (66.14)	139 (61.23)	Ref
>70 years old, n (%)	173 (36.19)	85 (33.86)	88 (38.77)	1.24 (.85-1.80)
Gender, n (%)				
Male	237 (49.58)	139 (55.38)	98 (43.17)	Ref
Female	241 (50.42)	112 (44.62)	129 (56.83)	1.63 (1.14-2.35)
Race/ethnicity, n (%)				
Non-Hispanic White	276 (57.74)	140 (55.78)	136 (59.91)	Ref
Non-Hispanic Black	111 (23.22)	58 (23.11)	53 (23.35)	.94 (.61-1.46)
Hispanic	77 (16.11)	46 (18.33)	31 (13.66)	.69 (.42-1.16)
Initial NIHSS, n (%)				
≤5	168 (35.15)	87 (34.66)	81 (35.68)	Ref
>5	300 (62.76)	160 (63.75)	140 (61.67)	.94 (.64-1.37)

Abbreviations: NIHSS, National Institutes of Health Stroke Scale.
[†]For quantitative variables Kruskal-Wallis test are used to assess the differences between 2 groups. For categorical variables Logistic Regression are employed for statistical comparison.

Table 6. *Door-to-needle-time variability among spoke characteristics and code stroke workflow*

	n = 478	≤60 min n = 251	>60 min n = 227	OR (CI)[†]	Adjusted OR (CI)[‡]
Years in TS Network, n (%)					
˚≤3 y	215 (44.98)	110 (43.82)	105 (46.26)	Ref	Ref
˚>3 y	263 (55.02)	141 (56.18)	122 (53.74)	.91 (.63-1.30)	.89 (.61-1.31)
Average no. of consults, n (%)					
˚≤10/month	99 (20.71)	54 (21.51)	45 (19.82)	Ref	Ref
˚>10/month	379 (79.29)	197 (78.49)	182 (80.18)	1.11 (.71-1.73)	1.07 (.67-1.69)
No. of beds at spoke, n (%)					
˚≤ 300 beds	209 (43.72)	110 (43.82)	99 (43.61)	Ref	Ref
˚>300 beds	269 (56.28)	141 (56.18)	128 (56.39)	1.01 (.70-1.45)	1.03 (.70-1.49)
In-house neuro coverage, n (%)					
˚None or part time	271 (56.69)	144 (57.37)	127 (55.95)	Ref	Ref
˚Full time	207 (43.31)	107 (42.63)	100 (44.05)	1.06 (.74-1.52)	1.03 (.71-1.49)
Prenotification protocol, n (%)					
˚No	395 (82.64)	209 (83.27)	186 (81.94)	Ref	Ref
˚Yes	83 (17.36)	42 (16.73)	41 (18.06)	1.10 (.68-1.76)	1.03 (.63-1.67)
Medically underserved, n (%)					
˚No	327 (68.41)	175 (69.72)	152 (66.96)	Ref	Ref
˚Yes	151 (31.59)	76 (30.28)	75 (33.04)	1.14 (.77-1.67)	1.15 (.77-1.72)
TS Page after CT scan, n (%)					
˚No	132 (27.6)	88 (35.1)	44 (19.4)	Ref	Ref
˚Yes	346 (72.4)	163 (64.9)	183 (80.6)	2.25 (1.48-3.41)	2.23 (1.45-3.43)
DTPT, n (%)					
˚≤15 min	227 (47.5)	176 (70.1)	51 (22.5)	Ref	Ref
˚>15 min	251 (52.5)	75 (29.9)	176 (77.5)	8.09 (5.36-12.23)	8.84 (5.72-13.67)

Abbreviations: DTPT, door-to-page-time; TS, Telestroke.
[†]For categorical variables Logistic Regression are employed for statistical comparison.
[‡]Adjusted for age, gender, race/ethnicity, initial National Institutes of Health Stroke Scale.

network in Georgia reported prolonged median DTNT, between 3/2011 and 11/2012, of 88 minutes (IQR 75-105) among 115 patients, with only 13% meeting a DTNT of less than 60 minutes, which was attributed to delayed times from patient arrival to TS patient registration.[6] We conducted a larger study to define and replicate those factors associated with prolonged door to TM activation. The wide variability of DTPT in our study gives us the opportunity to identify which hospitals have better practices that could be implemented at other spokes in our network.

A major lesson that we learned from our analysis is that obtaining a brain CT scan prior to TS alert was associated with delayed DTPT, as well as delayed DTNT. Spoke teams often await CT brain completion to rule out brain tumors or hemorrhage, prior to involving our telemedicine team. However, alerting the telemedicine team earlier may allow the TS physician to discuss the case with the Emergency Medical Services members, or family if they are available at the bedside. Additional information needed to evaluate tPA candidacy (ie, vital signs, prior admission records, labs, and medications lists) could be obtained from electronic medical charts or from the spoke nurse, while awaiting completion of the CT. This could apply even in EDs that have protocols in place wherein suspected stroke patients are transported directly to CT scan first. Connectivity and quality of communication can be assessed prior to CT completion as well. If another etiology is found on CT scan, the TS alert could be cancelled, or the TS physician could also provide recommendations on acute management or patient transfer. Most patients in our study had a CT completed in the recommended guideline of 25 minutes,[8] however, the majority also underwent CT scan prior to the TS alert. Certain steps in acute AIS pathways may have a different emphasis when patients are evaluated via TS, in order to meet reperfusion metric goals.

DTPT was less likely to be delayed when patients presented with more severe stroke symptoms, however, DTNT was not dependent on stroke severity in this study. Prior findings for patients evaluated in settings not dependent on TS found DTNT meeting the 60-minute goal was associated with more severe strokes.[10] One third of patients with mild stroke who are otherwise eligible for tPA, but do not receive tPA, are disabled at discharge and at 90 days.[12,13] TS involvement may attenuate some delays in treatment time, however our findings suggest a role for further education on recognizing more subtle stroke symptoms for spokes who may not be as familiar with diagnosing mild stroke.

DTPT was similar between male and female patients, whereas DTNT is more likely to be delayed for female patients than male patients, which warrants further investigation beyond the focus of this manuscript.

We extensively studied the size of hospitals as a variable that would affect AIS metrics. Larger hospitals with more than 300 patient beds were more likely to have delayed DTPT but the size of the hospital did not affect the DTNT. It is not clear why the number of inpatient beds in a spoke would affect tPA metrics in the ER. Potentially, time and attention allocated to non-TS cases (such as trauma, cardiac, or pulmonary admissions) compete with TS cases and could affect tPA metrics and workflow, although we lack numbers by spoke regarding non-TS case volumes. Larger hospitals may have increased nurse and physician caseloads than smaller hospitals which could also contribute to delayed TS physician alert. In addition, dissemination of information in larger hospitals may also be more difficult, making it harder to train TS pathways into a hard process. Once the TS physician is alerted and involved in the case, additional attention can be allocated and directed to tPA metrics and standard of care treatment for acute IS, possibly explaining why DTNT did not differ based on hospital size.

Spokes located in MUAs did not appear to have significantly different DTPT nor DTNT. These hospitals, acknowledging limited resources, may more readily expedite the TS notification process. Interestingly, the volume of TS consults per month at spokes did not affect DTPT nor DTNT. Spokes that were in our TS network for more than 3 years may have been less likely to have delayed DTPT, although in our analysis this was not a statistically significant difference. Increased experience and exposure to TS and AIS workflow would intuitively lead to improved metrics, and in settings that are not dependent on TS for acute stroke care, increased hospital experience with stroke patients was associated with DTNT less than or equal to 60 minutes.[10] This may reflect constant turnover of ED nurses and ancillary staff, attenuating any effect of increased exposure to TS and acute IS.

Prenotification protocols have improved AIS management and tPA administration metrics for code strokes managed in settings not dependent on TS.[8,11] Interestingly, in our study, while prenotification protocols appeared to have an association with shorter DTPT, this did not reach statistical significance. This may be because, at the time of data collection, only 2 of the 17 spokes had established prenotification protocols, and thus this issue warrants additional investigation as more spokes may have adopted prenotification protocols since the time of this study.

The association of the presence of in-house full-time neurology coverage and shorter DTPT, even though an in-house neurologist and TS physician would not evaluate the same patient, may reflect continuing education efforts of the in-house neurologists. In some cases the in-house neurologists cover AIS patients and their intermittent physical presence in the ER may encourage timely AIS alerts.

The wide range and delay in TS alerts and tPA administration metrics suggests a role for sharing best practices and reviewing metrics of spokes together within a TS network. While spokes with delayed metrics may be apprehensive about sharing data initially, bringing attention to delays at a spoke within a TS network can drive improved care. Acknowledging which spoke characteristics and AIS workflows lead to better tPA metrics can be beneficial for the entire network. In addition, as TS networks continue to develop, and as new TS networks emerge, transparency of sharing data nationwide could also improve metrics and AIS care. Sharing AIS data, including patient characteristics and tPA administration data, among stroke centers in Southeast Texas improved tPA administration frequency and tPA administration metrics.[14]

Our findings are limited in that data were reviewed from the TS registry retrospectively. We also lack long term clinical outcomes, which warrant further study, although tPA administration via TS has been shown to be safe and efficacious in several prior studies.[15-17] In addition, the time from initial TS page to the decision whether to give tPA or not was not available due to incomplete data in this patient population but would be a useful metric to investigate. In spite of our larger study, it is still possible that it may be underpowered to detect more subtle differences in metrics between patient- and spoke-level characteristics. Generalizability among other TS networks is important to assess as well, as our data came from a single hub-and-spoke network.

We have demonstrated a wide range in time metrics for the activation of code strokes among spokes within our TS network. Our findings support the need for defined and standardized measures and workflow in AIS care over TS in order to continue to decrease disparities. DTPT and DTNT should meet an expected standard for all AIS patients, with or without TS. However, in order to meet an acceptable DTNT, AIS metrics may need adjustment over TS compared to standardized metrics for in-person code strokes. Further work is needed to improve and define TS metrics and establish TS workflow.

Declaration of Competing Interest

No conflict of interest.

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