

# No Weekend or After-Hours Effect in Acute Ischemic Stroke Patients Treated by Telemedicine

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*Background:* Stroke outcomes have been shown to be worse for patients presenting overnight and on weekends (after-hours) to stroke centers compared with those presenting during business hours (on-hours). Telemedicine (TM) helps provide evaluation and safe management of stroke patients. We compared time metrics and outcomes of stroke patients who were assessed and received intravenous recombinant tissue plasminogen activator (IV-tPA) via TM during after-hours with those during on-hours. *Methods:* Analysis of our TM registry from September 2015 to December 2016, identified 424 stroke patients who were assessed via TM and received IV-tPA. We compared baseline characteristics, clinical variables, time metrics, and outcomes between the after-hours (5 pm–7:59 am, weekends) and on-hours (weekdays 8 am–4:59 pm) patients. *Results:* Of the 424 patients, 268 were managed via TM during after-hours, and 156 during on-hours. Baseline characteristics and clinical variables were similar between the groups. Importantly, there were no differences in all relevant time metrics including door to IV-tPA bolus time. IV-tPA complications (including all intracerebral hemorrhage (ICH), any systemic bleeding, and angioedema), discharge disposition, and 90-day modified Rankin Scale were also similar in the groups. *Conclusions:* There was no difference in IV-tPA treatment times, acute stroke evaluation times, or mortality between the patients treated after-hours versus on-hours. Unlike in-person neurology coverage at many centers, the coverage provided by TM does not differ depending on the hour or day. Access to stroke specialists 24/7 via TM can ensure dependable and timely clinical care for acute stroke patients regardless of the time of day or day of the week.

**Key Words:** Stroke—Telemedicine—Time metrics—Thrombolytics

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## Introduction

In 2013, stroke declined to the fifth leading cause of death in the United States. While overall stroke mortality has decreased over the past decade, there has been little change in geographic disparities, and people living in rural areas have disproportionately high rates of death

due to stroke.<sup>1,2</sup> For 2 decades, thrombolysis with intravenous recombinant tissue-type plasminogen activator (IV-tPA) was the only approved therapy for acute ischemic stroke (AIS), with the highest IV-tPA utilization and best outcomes observed when patients present to stroke centers.<sup>3</sup> However, stroke care access studies have shown

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that only 55%-66% of the United States population lives within 60 minutes' ground access to a Joint Commission certified primary stroke center.<sup>4</sup> The application of telemedicine (TM) has increased patient access to neurological expertise and evidence-based stroke treatment.<sup>5</sup> IV-tPA via TM by vascular neurologists has been shown to be safe, with functional outcomes, complication rates, and mortality rates comparable to those patients presenting directly to stroke centers.<sup>6,7</sup>

Although management of acute stroke patients in stroke centers has been correlated with decreased mortality and good functional outcomes, there is evidence that stroke outcomes can be affected by the day and time of hospital presentation – with higher mortality in patients presenting overnight or on weekends compared to those of patients presenting during typical weekday business hours – the so called “weekend effect.”<sup>8,9</sup> To our knowledge, variation in patient care and outcomes based on time or day of hospital presentation has not been studied in stroke patients managed via TM at community hospitals. We explored this question in our telestroke network of community hospitals where TM is intended to provide remote stroke consultation during the day and night 7 days per week staffed by stroke neurologists on a rotating schedule. We hypothesized that hospitals with continuous availability of remote telestroke expertise would have consistent acute treatment care and patient outcomes, regardless of the day or time of presentation.

## METHODS

### *Data Sources*

Our TM program maintains a registry of all consultations performed on patients presenting with suspected stroke to community hospitals in Texas. The Lone Star Stroke Consortium Telestroke Registry (LESTER) registry is a statewide registry with established policies and procedures that dictate how data are gathered. Furthermore, the full methods manuscript is under submission for publication. Data from our spoke sites are abstracted from the emergency department (ED) electronic medical records by registry personnel and provided by stroke coordinators and entered into a secure database using REDCap software. TM related time metrics (page time and camera time) are collected from TM physician logs and clinical notes by registry personnel. TM physicians keep a templated consult log that they use to track page times and this metric can also be reconciled with data provided from our central call center. TM physicians are also required to document into templated clinical notes the time they get on camera. Data from our hub site are retrospectively collected from our electronic medical records for all presumptive stroke patients seen through TM, and 90 day baseline modified Rankin Scale (mRS) scores are also collected. Electronic codebook is used as guide for data entry.

We retrospectively reviewed our prospectively collected data of all TM consultations performed by the UTHealth Teleneurology program from September 2015 to December 2016. We identified 425 consecutive AIS patients who were urgently evaluated via TM and received IV-tPA within 4.5 hours of symptom onset. One patient was excluded after data quality check, yielding 424 patients included in our analysis. We collected demographic information, baseline mRS scores, initial National Institutes of Health Stroke Scale (NIHSS) scores, time metrics, complications, discharge disposition, and 90-day outcomes obtained by telephone interview.

### *Telemedicine Framework*

During the study, our Teleneurology program (hub) provided acute neurologic coverage for 15 spoke hospitals in a 250 mile radius. Urgent neurological consultations are received via pager 24 hours a day, 7 days a week, by a rotating team of vascular neurologists. When a patient with a suspected neurological emergency arrives at a spoke hospital, he or she is urgently evaluated, a non-contrasted computed tomography (CT) of the head is typically obtained, and an urgent TM consultation is paged by the spoke hospital. When the page is received by the on call neurologist, he or she calls the requesting provider back to discuss the case, reviews imaging if available, and then evaluates the patient via our TM video platform, InTouch Health RP-Lite. Patients with suspected AIS are managed according to American Heart Association guidelines. For each consult, the treating team is encouraged to recontact the TM team if the patient deteriorates.

### *Definition of Metrics*

“Page time” is defined as the time when the Vascular Neurologist received the urgent consultation page from our centralized call center and is documented in a templated physician call log, and “camera time” was when the Vascular Neurologist began the TM assessment of the patient and is documented into the clinical consultation note.

### *Outcomes*

The primary outcome of this study was door time to IV-tPA bolus time. A secondary outcome was tPA-related complications, including symptomatic intracranial hemorrhage (sICH)—defined as hemorrhage seen on CT or magnetic resonance imaging performed within 36 hours of tPA administration, and an associated 4-point increase or greater on the patient's NIHSS score—as well as any systemic bleeding or angioedema. These 2 outcomes were chosen because they refer to clinical care provided at the community hospital. For tertiary outcomes, we collected length of stay (LOS) defined as the number of days from hospital admission to discharge, in-hospital mortality,

and long-term clinical outcome was determined by 90-day mRS. A mRS 0-2 was considered favorable outcome and mRS 3-6 was considered poor outcome.

#### *On Versus After-Hours*

“On-hours” are defined as weekdays (Monday-Friday) from 08:00 to 16:59 hours, and “after-hours” are defined as weekdays from 17:00 to 07:59 hours and weekends (Friday 17:00-Monday 07:59).

#### *Statistics*

Distribution of all variables was examined for appropriateness of distribution assumptions. Demographic information, baseline characteristics, clinical metrics, and outcomes were reported by frequency and percentage for categorical variables, mean and standard deviations for continuous variables with normal distribution, and median and interquartile ranges for continuous variables with skewed distribution. The comparison of these variables between patients managed “on-hours” and “after-hours” was conducted by either 2-sample *t*-test or Wilcoxon rank sum test for continuous variables, and Chi-square test or Fisher's exact test for categorical variables. Regarding time metrics, median and interquartile ranges were reported, and Wilcoxon rank sum test was used to compare their distributions between patients managed on-hours and after-hours.

Multivariable quantile regression model was fitted to compare the median door to IV-tPA bolus time and LOS, and multivariable logistic regression model was fitted for secondary outcomes including in-hospital mortality, 90-day favorable outcome, and 90-day mortality between 2 groups after controlling for the effect of confounders. The identification of confounders was based on both a priori and empirical considerations. First, variables shown previously to be correlated with patient outcomes (eg, age, NIHSS at presentation, vascular neurologist training experience, and experience of spoke hospital) were included in the multivariable model. Second, we identified the factors which both differed between 2 groups and were associated with outcomes with *P* value < .20 in univariable analyses. Then we included those covariates into the final model only if adding to or deleting them from the multivariable model, the regression coefficient of the group indicator (on-hours and after-hours) varied by >20%. The adjusted median difference and the adjusted odds ratio (OR) as well as their 95% confidence intervals (CI) were reported.

In addition, we conducted subgroup analysis in the transferred and non-transferred patients, respectively. Transferred patients are defined as those who were initially evaluated and treated by TM and then were transferred to another hospital; otherwise, they were considered as non-transferred patients. All analyses were

performed using SAS 9.4 (SAS Institute Inc., Cary, NC) and a *P* value less than .05 was considered significant.

## **Results**

### *Descriptive Statistics*

A total of 424 patients were included in the analysis. Of these patients, 268 (63.2%) were managed via TM during after-hours, and 156 (36.8%) were managed during on-hours. The mean (SD) age was 63.6 (16.5 SD) years, and 50.0% of the patients were female. Regarding racial groups, 59.1% were White, 23.0% were Black, 16.3% were Hispanic, and 1.7% were Asian. The percentage of patients with baseline mRS <2 and median initial NIHSS scores were similar between the after-hours and on-hours groups. Over half of the patients (52%) were transferred to another hospital after initial evaluation in the ED of the community hospital. Overall, the baseline characteristics and clinical variables were similar between the groups (Table 1).

### *Time Metrics*

The door to CT time and the page to camera time were longer in the after-hours group compared to the on-hours group (8 minutes versus 6 minutes, *P* = .05 and 10 minutes versus 8 minutes *P* = .002, respectively). However, last known well to door, door to page, door to camera, CT to camera, door to IV-tPA bolus, camera to IV-tPA bolus, and all other time metrics were similar between the groups (Table 2). After controlling for potential confounding effects (age, NIHSS at presentation, vascular neurologist training experience, and experience of the spoke hospital), we did not see statistically significant differences on median door to CT time (adjusted median difference -0.8 minute, 95% CI: -7.3-5.7 minutes, *P* = .91), but we still see statistical significant difference on page to camera time (adjusted median 1.6, 95% CI: .5, 2.6, *P* = .003) between the 2 groups.

### *Outcomes*

Overall sICH was 4.5% (19/424). There was no significant difference in sICH in patients admitted after-hours as compared to those admitted on-hours. Similarly, there was no significant difference in any post-IV-tPA complications between the groups (Table 3). The overall median (IQR) LOS was 4 days (2-7 days), and with the median LOS in the after-hours group and the on-hours group at 4 days versus 3 days. After controlling for potential confounding effects (age, NIHSS at presentation, vascular neurologist training experience, and experience of the spoke hospital), we observed .7 (95% CI: 0, -1.4) day longer median LOS in the after-hours group compared with the on-hours group, which is marginal significantly (*P* = .05). Over 59% of patients were discharged home and over 19% were discharged to rehab, with no significant

**Table 1.** Comparison of demographics and medical history between patients admitted during on-hours and after-hours time window

| Variable  | Total (N = 424) | After-hours (N = 268) | On-hours (N = 156) | P value           |
|---|-----------------|-----------------------|--------------------|-------------------|
| Age, mean $\pm$ SD                                    | 63.6 $\pm$ 16.5 | 63.6 $\pm$ 17.1       | 63.4 $\pm$ 15.5    | .89 <sup>‡</sup>  |
| Male, n (%)   | 212 (50.0)      | 130 (48.5)            | 82 (52.6)          | .42*              |
| Race, n (%)   |                 |                       |                    | .47 <sup>†</sup>  |
| Asian   | 7 (1.7)         | 6 (2.3)               | 1 (0.6)            |                   |
| Black or AA   | 96 (23.0)       | 64 (24.2)             | 32 (20.8)          |                   |
| Hispanic  | 68 (16.3)       | 44 (16.7)             | 24 (15.6)          |                   |
| White   | 247 (59.1)      | 150 (56.8)            | 97 (63.0)          |                   |
| Prior stroke - ischemic, n (%)                        | 95 (22.4)       | 54 (20.1)             | 41 (26.3)          | .14*              |
| Prior stroke - hemorrhagic, n (%)                     | 9 (2.1)         | 6 (2.2)               | 3 (1.9)            | 1.00 <sup>†</sup> |
| Transient ischemic attack, n (%)                      | 37 (8.7)        | 20 (7.5)              | 17 (10.9)          | .23*              |
| Hypertension, n (%)                                   | 294 (69.3)      | 181 (67.5)            | 113 (72.4)         | .29*              |
| Coronary artery disease/ myocardial infarction, n (%) | 76 (17.9)       | 42 (15.7)             | 34 (21.8)          | .11*              |
| Congestive heart failure, n (%)                       | 41 (9.7)        | 28 (10.4)             | 13 (8.3)           | .48*              |
| Atrial fibrillation/ flutter, n (%)                   | 56 (13.2)       | 41 (15.3)             | 15 (9.6)           | .10*              |
| Hypercholesterolemia/hypertriglyceridemia, n (%)      | 150 (35.4)      | 93 (34.7)             | 57 (36.5)          | .70*              |
| Diabetes mellitus, n (%)                              | 129 (30.4)      | 84 (31.3)             | 45 (28.8)          | .59*              |
| Tobacco, n (%)  | 164 (39.0)      | 98 (36.7)             | 66 (43.1)          | .19*              |
| Anticoagulant use, n (%)                              | 22 (5.2)        | 16 (6.0)              | 6 (3.9)            | .35*              |
| Antiplatelet use, n (%)                               | 172 (40.6)      | 104 (38.8)            | 68 (43.6)          | .33*              |
| Premorbid mRS, n (%)                                  |                 |                       |                    | .71*              |
| 0-2   | 297 (82.5)      | 181 (81.9)            | 116 (83.5)         |                   |
| 3-5   | 63 (17.5)       | 40 (18.1)             | 23 (16.5)          |                   |
| NIHSS, median (Q1, Q3)                                | 8.0 (5.0, 15.0) | 8.0 (5.0, 16.0)       | 7.0 (4.0, 15.0)    | .37 <sup>§</sup>  |
| Consultant, n (%)                                     |                 |                       |                    | <.001*            |
| Attending   | 367             | 244 (91.0)            | 123 (78.9)         |                   |
| Fellow  | 57              | 24 (.0)               | 33 (21.2)          |                   |

mRS, modified Rankin Scale; N, total number; n, a sample of the total number; NIHSS, National Institutes of Health Stroke Scale.

\*P values obtained by chi-square test.

<sup>†</sup>P values obtained by Fisher's exact test.

<sup>‡</sup>P values obtained by 2 sample t-test.

<sup>§</sup>P values obtained by Wilcoxon rank sum test.

difference in discharge disposition based on day of presentation. Overall, we did not see any significant difference between on-hours and after-hours for mortality at Day 90. The adjusted OR of mortality at Day 90 for on-hours versus after-hours was .94 (95% CI: .41, 2.20,  $P = .89$ ). Functional outcome as measured by the 90-day mRS, were also similar between the 2 groups (adjusted OR = .96, 95% CI: .54-1.71,  $P = .89$ ). Furthermore, patients presenting overnight and on weekends were not more likely to expire or be discharged to hospice than those presenting on weekdays (Table 4).

We conducted a subgroup analysis in transferred patients and non-transferred patients, respectively. For transferred patients, we observed similar findings as that in the whole cohort. After controlling for potential confounding effects, we did not see significant differences for door to IV-tPA bolus time ( $P = .79$ ), LOS ( $P = .20$ ), favorable outcome at Day 90 (on-hour versus after-hour, adjusted OR = .83, 95% CI: .41-1.69,  $P = .61$ ), in-hospital mortality (on-hour versus after-hour, adjusted OR = 1.47, 95% CI: .52-4.18,  $P = .47$ ), and mortality at Day 90 (on-hour versus after-hour, adjusted OR = .88, 95% CI: 0.31-2.49,  $P = .81$ ).

For non-transferred patients, similarly, we did not observe any statistically significant findings for door to IV-tPA bolus time, LOS, in-hospital mortality, and mortality at Day 90 after controlling for age, NIHSS at presentation, vascular neurologist experience, spoke hospital experience, and history of prior ischemic stroke. However, the odds of having a favorable outcome at Day 90 in the on-hours group were more than three times higher than in the after-hours groups (adjusted OR = 3.62, 95% CI: 1.02-12.87,  $P = .02$ ).

## Discussion

Several previous studies have found higher mortality among ischemic stroke patients admitted on weekends and overnight compared to those admitted on weekdays.<sup>8,9</sup> One study found that quality of care was at least partially a factor associated with increased mortality for stroke patients admitted on weekends.<sup>10</sup> At some hospitals, patients admitted on weekends have lower IV-tPA treatment rates<sup>11</sup> and longer delays to acute stroke evaluation in the ED,<sup>12</sup> compared with patients admitted during the weekday. However, the "weekend effect" does not

**Table 2.** Comparison of time metrics between patients admitted during on-hours and after-hours time window

| Variable                                      | Total (N = 424)                 | After-hours (N = 268)           | On-hours (N = 156)              | P value |
|---|---------------------------------|---------------------------------|---------------------------------|---------|
| Last known well to door/ED arrival time (min) | N = 421<br>68.0 (43.0, 120.0)   | N = 266<br>65.0 (40.0, 125.0)   | N = 155<br>73.0 (45.0, 115.0)   | .41     |
| Last well to CT time (min)                    | N = 421<br>79.0 (51.0, 136.0)   | N = 266<br>76.0 (50.0, 140.0)   | N = 155<br>82.0 (52.0, 133.0)   | .71     |
| Last well to page time (min)                  | N = 421<br>95.0 (59.0, 148.0)   | N = 266<br>90.5 (57.0, 149.0)   | N = 155<br>99.0 (61.0, 143.0)   | .34     |
| Last well to camera time (min)                | N = 398<br>104.5 (70.0, 160.0)  | N = 250<br>102.0 (69.0, 162.0)  | N = 148<br>108.5 (70.5, 153.0)  | .64     |
| Door to CT time (min)                         | N = 424<br>7.0 (3.0, 15.0)      | N = 268<br>8.0 (3.0, 16.0)      | N = 156<br>6.0 (1.0, 13.0)      | .05     |
| Door to page time (min)                       | N = 424<br>17.0 (10.0, 28.5)    | N = 268<br>16.5 (10.0, 28.0)    | N = 156<br>17.5 (11.0, 31.5)    | .25     |
| Door to camera time (min)                     | N = 401<br>28.0 (20.0, 39.0)    | N = 252<br>28.0 (20.0, 39.0)    | N = 149<br>27.0 (19.0, 41.0)    | .84     |
| CT to camera time (min)                       | N = 401<br>19.0 (11.0, 29.0)    | N = 252<br>19.0 (10.0, 29.5)    | N = 149<br>18.0 (13.0, 28.0)    | .30     |
| Page to camera time (min)                     | N = 401<br>9.0 (7.0, 12.0)      | N = 252<br>10.0 (8.0, 12.0)     | N = 149<br>8.0 (6.0, 11.0)      | .002    |
| Last known well to IV-tPA bolus time (min)    | N = 421<br>143.0 (103.0, 192.0) | N = 266<br>141.5 (102.0, 193.0) | N = 155<br>150.0 (104.0, 192.0) | .37     |
| Door time to IV-tPA bolus time (min)          | N = 424<br>59.0 (47.0, 80.0)    | N = 268<br>59.0 (47.0, 79.5)    | N = 156<br>61.0 (47.0, 81.0)    | .62     |
| CT to IV-tPA bolus time (min)                 | N = 424<br>49.0 (37.0, 65.0)    | N = 268<br>49.0 (37.0, 64.0)    | N = 156<br>49.5 (37.0, 68.0)    | .32     |
| Page to IV-tPA bolus time (min)               | N = 424<br>39.0 (32.0, 52.0)    | N = 268<br>40.0 (32.0, 52.0)    | N = 156<br>38.0 (30.0, 52.0)    | .57     |
| Camera to IV-tPA bolus time (min)             | N = 401<br>29.0 (22.0, 42.0)    | N = 252<br>29.0 (22.0, 41.0)    | N = 149<br>28.0 (22.0, 43.0)    | .78     |
| tPA recommendation to IV-tPA bolus (min)      | N = 214<br>8.0 (4.0, 16.0)      | N = 135<br>8.0 (4.0, 17.0)      | N = 79<br>8.0 (4.0, 15.0)       | .74     |

CT, computed tomography; ED, emergency department; tPA, tissue plasminogen activator.

Data were represented as median (1st quartile, 3rd quartile). P values were obtained by Wilcoxon rank sum test.

appear to exist at hospitals that are certified as comprehensive stroke centers (CSC), which provide continuous higher level services for more complex and acute cases,<sup>13</sup> irrespective of the day. Community hospitals unfortunately do not have CSC-level resources and personnel during after-hours and weekends, possibly leading to slower evaluation and treatment of stroke patients. Ambulances transporting suspected acute stroke patients may even bypass stroke centers with slow response times if they cannot provide rapid services. The implementation of TM in some healthcare systems has successfully increased IV-tPA treatment rates and reduced IV-tPA treatment times for acute stroke patients at community hospitals.<sup>14</sup>

To address our hypothesis, we focused on IV-tPA time metrics as the primary outcome because symptom onset time to IV-tPA treatment is a major predictor of clinical outcome.<sup>15</sup> Arrival at an ED to IV-tPA treatment time is a national benchmark that hospitals must collect as part of Centers for Medicare and Medicaid Services reporting and as part of Joint Commission core measures. When comparing on-hours versus after-hours, we indeed found no differences in ED arrival to IV-tPA treatment, but did

find a trend suggesting a small 2 minute delay in obtaining a CT after-hours compared with on-hours. However, time from ED arrival to TM consult activation by the ED staff and ED arrival to CT acquisition were not different between the groups. These latter time metrics would have been expected to be longer after-hours/weekends. One possibility is that regular education provided by our TM team may affect ED response times. We also found that there were no differences in complications from IV-tPA including symptomatic hemorrhages and angioedema. These results suggest that IV-tPA is safe to administer regardless of the time of presentation to community hospitals with telestroke expertise.

We assessed a range of outcomes in IV-tPA treated patients evaluated by TM. The weekend effect was originally reported as a concern that stroke patients hospitalized on weekends have a higher mortality compared with patients admitted during week days.<sup>8</sup> In patients with acute stroke evaluated by TM, we found there was no difference in mortality between on-hours and after-hours, further supporting that the use of TM for acute stroke patients is not associated with a weekend effect at community

**Table 3.** Comparison of clinical outcomes between patients admitted during on-hours and after-hours time window

| Variable                        | Total (N = 424)           | After-hours (N = 268)     | On- hours (N = 156)       | P value          |
|---------------------------------|---------------------------|---------------------------|---------------------------|------------------|
| NIHSS at 24 h, median (Q1, Q3)  | N = 330<br>3.0 (1.0, 8.0) | N = 209<br>3.0 (0.0, 9.0) | N = 121<br>3.0 (1.0, 8.0) | .68 <sup>†</sup> |
| Length of stay, median (Q1, Q3) | N = 413<br>4.0 (2.0, 7.0) | N = 262<br>4.0 (2.0, 7.0) | N = 151<br>3.0 (2.0, 7.0) | .09 <sup>†</sup> |
| tPA complication, n (%)         | N = 413<br>55 (13.3)      | N = 262<br>35 (13.4)      | N = 151<br>20 (13.2)      | .97*             |
| Symptomatic ICH, n (%)          | N = 424<br>19 (4.5)       | N = 268<br>11 (4.1)       | N = 156<br>8 (5.1)        | .62*             |
| Nonsymptomatic ICH, n (%)       | N = 424<br>18 (4.2)       | N = 268<br>11 (4.1)       | N = 156<br>7 (4.5)        | .85*             |
| Disposition discharge, n (%)    | N = 413                   | N = 262                   | N = 151                   | .49*             |
| Home                            | 246 (59.6)                | 155 (59.2)                | 91 (60.3)                 |                  |
| Hospice/expired                 | 32 (7.7)                  | 20 (7.6)                  | 12 (7.9)                  |                  |
| Rehab                           | 81 (19.6)                 | 48 (18.3)                 | 33 (21.9)                 |                  |
| SNF/NH/LTCH/other               | 54 (13.1)                 | 39 (14.9)                 | 15 (9.9)                  |                  |
| mRS at day 90, n (%)            | N = 274                   | N = 164                   | N = 110                   | .92*             |
| 0-2                             | 146 (53.3)                | 87 (53.1)                 | 59 (53.6)                 |                  |
| 3-6                             | 128 (46.7)                | 77 (46.9)                 | 51 (46.4)                 |                  |
| mRS at day 90, n (%)            | N = 274                   | N = 164                   | N = 110                   | .69*             |
| 0-1                             | 100 (36.5)                | 57 (34.8)                 | 43 (39.1)                 |                  |
| 2-3                             | 86 (31.4)                 | 50 (30.5)                 | 36 (32.7)                 |                  |
| 4-5                             | 46 (16.8)                 | 29 (17.7)                 | 17 (15.5)                 |                  |
| 6                               | 42 (15.3)                 | 28 (17.1)                 | 14 (12.7)                 |                  |

SD, standard deviation; AA, African-American; ICH, Intracerebral hemorrhage; SNF, skilled nursing facility; NH, nursing home; LTCH, long term care hospital.

\*P values obtained by chi-square test.

<sup>†</sup>P values obtained by Wilcoxon rank sum test.

hospitals. Furthermore, we also found that there was no difference in favorable outcomes at 90 days in patients admitted during on hours versus after-hours. However, half of the patients initially evaluated by TM at a community hospital were transferred to another hospital for a higher level of care. When we excluded transfer patients, we still found no difference in mortality no matter when

the patients presented to the community hospitals; however, patients admitted and not transferred during on-hours achieved better functional outcomes compared with patients presenting after-hours. These results suggest the possibility that hospital admission after acute care in the ED (ie, beyond the initial TM consultation and management) may be different during on-hours versus after-hours

**Table 4.** Adjusted odds ratio (OR) of secondary clinical outcomes in on-hours group compared to after-hours group through multi-variable logistic regression

| Outcome   | Adjusted OR (95% CI) | P value |
|---|----------------------|---------|
| <b>All patients</b>                                     |                      |         |
| Favorable outcome (mRS 0-2) at day 90                   | .96 (0.54, 1.71)     | .89     |
| In-hospital mortality (discharged to hospice/mortality) | 1.36 (0.59, 3.15)    | .48     |
| Mortality at day 90                                     | .94 (0.41, 2.20)     | .89     |
| <b>Non-transferred patients</b>                         |                      |         |
| Favorable outcome (mRS 0-2) at day 90                   | 3.62 (1.02, 12.87)   | .02     |
| In-hospital mortality (discharged to hospice/mortality) | 1.05 (0.22, 5.11)    | .95     |
| Mortality at day 90                                     | 1.55 (0.30, 7.98)    | .60     |
| <b>Transferred patients</b>                             |                      |         |
| Favorable outcome (mRS 0-2) at day 90                   | .83 (0.41, 1.69)     | .61     |
| In-hospital mortality (discharged to hospice/mortality) | 1.47 (0.52, 4.18)    | .47     |
| Mortality at day 90                                     | .88 (0.31, 2.49)     | .81     |

The adjusted OR were calculated after controlling for age, NIHSS at presentation, vascular neurologist experience, prior history of ischemic stroke (only for the outcomes in non-transferred patients), and experience of spoke hospital.

at community hospitals, leading to differences in long-term functional outcomes. The hospitals within our TM network range from urban community hospitals that are certified as primary stroke centers to rural critical care access hospitals. With our TM program, as with CSCs, there is a systematic approach to stroke care and stroke expertise is available 24/7 ensuring that acute stroke care is reliable irrespective of the time of day or day of the week.

Our study has several limitations. First, while our data were collected prospectively, the data were reviewed retrospectively. Second, our patient population was limited to those with ischemic stroke who received IV-tPA. Therefore, our study is not generalizable to patients with contraindications to IV-tPA administration and is not generalizable to patients beyond 4.5 hours after symptom onset, patients with intracerebral hemorrhage or patients with TIA. Fourth, we did not confirm if there were fewer staff after hours. Fifth, less than 2% of the patients were transferred to hospitals other than the hub, however, all of these patients were transferred to primary stroke centers within the hub system, and this would have no bearing on treatment time metrics such as door to IV-tPA bolus time, etc., but may have a small influence on outcomes, which are tracked and gathered by the LESTER registry. Sixth, there were only 10 state observed holidays on weekdays during the study period, which should have been considered after-hours, however this is unlikely to cause significant differences in results.

In conclusion, our study found no evidence of a “week-end effect” for stroke patients at hospitals equipped with telestroke services. Hospitals that cannot provide around the clock in-hospital acute stroke expertise may consider implementing TM on weekends and after-hours, as this may help to reduce mortality and potentially decrease long-term complications of stroke.

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