Telemedicine impact on post-stroke outpatient follow-up in an academic healthcare network during the COVID-19 pandemic

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Background: The expansion of telemedicine associated with the COVID-19 pandemic has influenced outpatient medical care. The objective of our study was to determine the impact of telemedicine on post-acute stroke clinic follow-up. *Methods:* We retrospectively evaluated the impact of telemedicine in Emory Healthcare, an academic healthcare system of comprehensive and primary stroke centers in Atlanta, Georgia, on post-hospital stroke clinic follow-up. We compared the frequency of 90-day follow-up in a centralized subspecialty stroke clinic among patients hospitalized before the local COVID-19 pandemic (January 1, 2019- February 28, 2020), during (March 1- April 30, 2020) and after telemedicine implementation (May 1- December 31, 2020). A comparison was made across hospitals less than 1 mile, 10 miles, and 25 miles from the stroke clinic. *Results:* Of 1096 ischemic stroke patients discharged home or to a rehab facility during the study period, 342 (31%) had follow-up in the Emory Stroke Clinic (comprehensive stroke center 46%, primary stroke center 10 miles away 18%, primary stroke center 25 miles away 14%). Overall, 90-day follow-up increased from 19% to 41% after telemedicine implementation ($p<0.001$) with telemedicine appointments amounting for up to 28% of all follow-up visits. In multivariable analysis, factors associated with teleneurology follow-up (vs no follow-up) included discharge from the comprehensive stroke center, thrombectomy treatment, private insurance, private transport to the hospital, NIHSS 0-5 and history of dyslipidemia. *Conclusions:* Despite telemedicine implementation at an academic healthcare network successfully increasing post-stroke discharge follow-up in a centralized subspecialty stroke clinic, the majority of patients did not complete 90-day follow-up during the COVID-19 pandemic.

Keywords: Telemedicine—Outpatient—Stroke—Follow-up

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Introduction

Outpatient follow-up after acute stroke plays a significant role in optimizing patient care, secondary stroke prevention and reducing morbidity and mortality.[1] As the risk of recurrent stroke is highest within the first six months following stroke, prompt outpatient follow-up is essential for secondary prevention of future complications and minimizing the risk of hospital readmission.[2-4] Outpatient in-person follow-up represents one strategy. However, the COVID-19 pandemic negatively impacted medical delivery in various specialties, including continuity of care.[5,6] Telemedicine provides an alternative strategy to evaluate and treat patients after discharge.[7] Understanding patient characteristics to identify those less likely to follow-up after discharge is important to design targeted interventions and increase follow-up rates.

The objective of this study was to assess the impact of implementing telemedicine on stroke patient follow-up after discharge in a large urban healthcare system.

Methods

This is a retrospective cohort study conducted in a large academic healthcare system in Atlanta, Georgia. It included patients from three hospitals - a large University hospital certified as a comprehensive stroke center (CSC), and two satellite hospitals certified as primary stroke centers (PSC) by the Joint Commission. A stroke clinic at the CSC provides central coordination of post-hospital outpatient comprehensive stroke care for the healthcare system, and the two PSCs are located 10 (PSC10) and 25 (PSC25) miles from the stroke clinic.

The study included ischemic stroke patients discharged home or to an acute or other healthcare facility from January 1, 2019 through December 31, 2020. Patients with Kaiser Permanente insurance who completed outpatient follow-up at Kaiser facilities were excluded from this analysis. Follow-up options included in-person or telemedicine; telemedicine services were gradually introduced on March 1, 2020 and were fully implemented by May 1, 2020, as detailed elsewhere.[8]

Data on follow-up status was obtained through retrospective chart review and was merged, using the Georgia Longitudinal ID, with the Georgia Coverdell Acute Stroke Registry data for the initial hospital admission information. Whether a patient had a follow-up in-person or via synchronous audio-video telemedicine encounters within 90 days post discharge was the primary outcome.

Based on implementation of telemedicine services, the study period was classified into three periods: pre-implementation (Jan 1, 2019 – Feb 29, 2020), implementation (Mar 1, 2020 – Apr 30, 2020), and the post-implementation (May 1, 2020 – Dec 31, 2020). The variables considered as potential determinants of patient follow-up include socio-demographic characteristics (age, gender, race/ethnicity, main source of medical insurance), event-related variables (mode of transport to the hospital, day of the week patient was discharged (weekday vs. weekend) and the hospital treated at (CSC vs. PSC10 vs. PSC25), patient's pre-admission conditions (pre-stroke modified Rankin score, ambulatory status prior to admission, past medical history and medications prior to admission), current disease characteristics (etiology of stroke, ambulatory status on admission, initial National Institute of Health Stroke Scale Score, initial presenting signs, comfort measures only status, nothing by mouth [NPO] status), treatment received (intravenous alteplase, intra-arterial alteplase or mechanical endovascular reperfusion), in-hospital complications (hospital-acquired pneumonia, deep vein thrombosis or pulmonary edema, nosocomial urinary tract infection), medications, instructions, and stroke education patients received at discharge, whether patient was assessed or received rehabilitation services, and patient's condition at discharge (modified Rankin score at discharge, ambulatory status at discharge, and discharge disposition).

Statistical Analysis

Follow-up within 90 days after discharge was analyzed both as binomial and multinomial outcome. For the latter, it was classified into three categories: no follow-up, follow-up in-person, and follow-up via telemedicine. All potential predictors were analyzed in bivariate analysis using chi-square tests, and a 0.1 level of significance was used as cutoff to include in the initial multivariable model to assess predictors of 90-day follow-up. Binomial and multinomial multivariable logistic regressions were applied and variables with an association at 0.1 or lower p-value were included in the final models. All statistical analyses were performed with SAS Enterprise Guide version 7.1 Copyright© (2014) SAS Institute Inc., Cary, NC, USA.

Results

Of the 1,096 subjects, 47% were female, 47% non-white, and the median age was 70 years (IQR: 59-80); 7% were uninsured or paid out of pocket, and 49% were treated at the CSC (Table 1). Overall, 31% of the patients received follow-up at the stroke clinic within 90 days of admission. Follow-up was more frequent among patients discharged at the CSC than the PSCs (CSC 46%, PSC10 18%, PSC25 14%; $p<0.001$), and increased from 19% to 41% after telemedicine implementation ($p<0.001$) with telemedicine appointments increasing from 11% to 28% of all follow-up visits ($p<0.001$).

In binomial multivariate logistic regression, patients discharged in the post implementation period were more than twice as likely to receive follow-up compared to those treated in the pre-implementation period (OR 2.11, 95% CI 1.47-3.03). Females, patients who had private

Table 1. *Characteristics of study subjects by 90-day follow up status*

Characteristic	Total n (%)	90-day Follow-up		
		No n (%)	Yes n (%)	p-value
Gender				
Male	584 (53.4)	418 (55.7)	166 (48.5)	0.03
Female	509 (46.6)	333 (44.3)	176 (51.5)	
Age group				
< 65 Yrs	411 (37.6	265 (35.3)	146 (42.7)	0.02
>= 65 Yrs	682 (62.4)	486 (64.7)	196 (57.3)	
Race group				
Non-Hispanic White	553 (52.7)	398 (55.4)	155 (47.0)	0.02
Non-Hispanic Black	418 (39.8)	266 (37.0)	152 (46.1)	
Hispanic and Other races	78 (7.4)	55 (7.6)	23 (7.0)	
Main source of medical insurance				
Medicare	543 (51.2)	383 (53.0)	160 (47.2)	0.0002
Medicaid	29 (2.7)	20 (2.8)	9 (2.7)	
Private insurance	260 (24.5)	148 (20.5)	112 (33.0)	
Two or more sources	156 (14.7)	113 (15.7)	43 (12.7)	
Self-pay/No insurance	73 (6.9)	58 (8.0)	15 (4.4)	
Hospital treated at				
PSC10	431 (39.4)	354 (47.1)	77 (22.5)	<0.0001
PSC25	124 (11.3)	107 (14.2)	17 (5.0)	
CSC	538 (49.2)	290 (38.6)	248 (72.5)	
Mode of transport to the hospital				
Emergency medical service	383 (35.8)	274 (37.3)	109 (32.4)	0.24
Private transport/Taxi/Other	433 (40.5)	294 (40.1)	139 (41.4)	
Transfer from other hospital	254 (23.7)	166 (22.6)	88 (26.2)	
Day of the week patient discharged				
Weekday	916 (83.8)	627 (83.5)	289 (84.5)	0.67
Weekend	177 (16.2)	124 (16.5)	53 (15.5)	
Discharge month				
Jan 2019 − Feb 2020	456 (41.7)	368 (49.0)	88 (25.7)	<0.0001
Mar 2020 − Apr 2020	116 (10.6)	75 (10.0)	41 (12.0)	
May 2020 − Dec 2020	521 (47.7)	308 (41.0)	213 (62.3)	

insurance compared to those with Medicare, patients who had past medical history of dyslipidemia or family history of stroke, patients who received intraarterial alteplase or thrombectomy, and those who were ambulating at discharge had higher odds of getting follow-up visits compared to their counterparts.

Conversely, patients treated at PSCs were less likely to receive follow-up than patients treated at the CSC (PSC10, OR=0.15; 95% CI: 0.10-0.24) and (PSC25, OR=0.12; 95% CI: 0.06-0.24). Similarly, having no medical insurance, being transported by EMS to the hospital for acute stroke care, past medical history of diabetes, and being discharged to a non-acute care facility were negatively associated with post-discharge follow-up.

We found that patients who used teleneurology for follow-up (vs no follow-up) were more likely to be discharged from CSC than PSCs, have private insurance vs Medicare, present to hospital through private transport/taxi (vs EMS or transfer from other hospital), have a history of dyslipidemia, have NIHSS 0-5, receive intra-arterial alteplase or thrombectomy, receive antidepressant at discharge and discharge to home (Table 3). In-person visits (vs no follow-up) were more common among those discharged from CSC, those with family history of stroke, NIHSS 0-5, those ambulating independently with or without device or ambulation with assistance of a person.

Discussion

After recognition of COVID-19 in metropolitan Atlanta, telemedicine services were gradually introduced on March 1, 2020, and were fully implemented by May 1, 2020 at Emory Healthcare. Despite the detrimental effects of the COVID-19 pandemic on healthcare delivery and follow-up,[5,6] the implementation of telemedicine services led to increased follow-up among patients admitted during this time when compared to patients admitted prior to telemedicine implementation.

Despite this improvement in follow-up rates after the introduction of telemedicine services, the majority of

Table 2. *Determinants of post discharge 90-day follow-up among ischemic stroke patients treated at urban academic healthcare system, 2019- 2020*

	Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Interval		p-value
Discharge month				
May 2020 − Dec 2020	2.114	1.473	3.034	0.0002
Mar 2020 − Apr 2020	1.938	1.131	3.319	
Jan 2019 − Feb 2020	Reference	Reference	Reference	
Facility patient discharged from	0.12	0.06	0.24	<.0001
PSC25	0.15	0.10	0.24	
PSC10	Referent	Referent	Referent	
CSC				
Female	1.39	1.01	1.90	0.04
Main source of medical insurance				0.0001
Self-pay/No insurance	0.28	0.14	0.59	
Two or more sources	1.23	0.77	1.96	
Private insurance	1.66	1.13	2.43	
Medicaid	1.07	0.43	2.67	
Medicare	Referent	Referent	Referent	
Mode of transport to the hospital				0.002
Emergency medical service	0.59	0.40	0.88	
Transfer from other hospital	0.43	0.27	0.69	
Private transport/Taxi/Other	Referent	Referent	Referent	
Past medical history of	0.85	0.55	1.32	0.47
Atrial fibrillation				
Dyslipidemia	1.43	1.02	1.99	0.04
Diabetes mellitus	0.63	0.45	0.90	0.01
Stroke	0.71	0.48	1.03	0.07
Family history of stroke	1.54	1.22	5.32	0.01
Received intra-arterial alteplase or thrombectomy	3.25	1.79	5.89	0.0001
Ambulatory status at discharge				0.09
Ambulate independently with or without device	1.86	0.86	4.00	
Ambulate with assistance from person	2.20	1.09	4.44	
Unable to ambulate	Referent	Referent	Referent	
NIH Stroke Scale score	2.03	1.00	4.10	0.14
0-5				
6-15	1.59	0.96	3.10	
>15	Referent	Referent	Referent	
Anti-depressant not prescribed at discharge	0.62	0.37	1.05	0.07
Discharge disposition				
Acute Care Facility	0.95	0.23	3.87	0.03
Other Health Care Facility	0.53	0.33	0.86	
Home	Referent	Referent	Referent	

patients did not follow-up within 90 days, with those further distanced being disproportionately impacted. Our findings are similar to those from a retrospective case-control study of stroke patients where only 52% presented to a scheduled follow-up clinic visit.[9] Patients admitted to PSC10 were less likely to follow-up than those admitted to CSC, and the lowest follow-up rates were among those admitted to PSC25. Physical proximity of the stroke clinic to the CSC likely played a role in this outcome and further investigation is needed to identify additional barriers.

Patients who received intra-arterial alteplase or thrombectomy during their admission had higher follow-up rates. For this patient subset, the CSC stroke quality team informed the clinical coordinator of patients without a scheduled follow-up appointment 2 months after discharge. The clinical coordinator contacted these patients via phone to schedule an appointment by 3 months. The benefit of post-discharge telephone communication and patient reminders has previously been established,[1] and our findings support this approach as a potential mechanism to benefit other patient groups with follow-up reminders after discharge.

However, multiple factors have been shown to impede care using telemedicine.[10] In our study, uninsured and self-pay patients were less likely to follow-up in-person and with telemedicine. Low follow-up rates among this

Table 3. *Determinants of post discharge 90-day follow-up method among ischemic stroke patients treated at urban academic healthcare system, 2019-2020*

Characteristic	Odds Ratio (95% CI)		p-value
	In-person Visit Vs. No follow-up	Teleneurology Vs. No follow-up	
Discharge month			
May 2020 − Dec 2020	0.92 (0.58, 1.44)	7.14 (3.92, 13.02)	<.0001
Mar 2020 − Apr 2020	0.14 (0.03, 0.62)	9.61 (4.62, 19.97)	
Jan 2019 − Feb 2020	Reference	Reference	
Hospital treated at			
PSC25	0.18 (0.08, 0.44)	0.10 (0.04, 0.24)	<.0001
PSC10	0.32 (0.19, 0.57)	0.08 (0.04, 0.14)	
CSC	Reference	Reference	
Gender			
Female	1.37 (0.90, 2.10)	1.34 (0.90, 1.98)	0.18
Male	Reference	Reference	
Main source of medical insurance			
Private insurance	1.46 (0.88, 2.43)	1.95 (1.22, 3.13)	0.001
Medicaid	1.14 (0.35, 3.76)	1.08 (0.34, 3.37)	
Two or more sources	1.66 (0.93, 2.98)	0.93 (0.47, 1.83)	
Self-pay/No insurance	0.30 (0.10, 0.95)	0.31 (0.13, 0.72)	
Medicare	Reference	Reference	
Mode of transport to the hospital			
Emergency medical service	0.64 (0.37, 1.08)	0.57 (0.34, 0.94)	0.01
Transfer from other hospital	0.63 (0.34, 1.18)	0.34 (0.19, 0.61)	
Private transport/Taxi/Other	Reference	Reference	
Past medical history of			
Atrial fibrillation	0.28 (0.13, 0.62)	1.64 (0.96, 2.80)	0.001
Dyslipidemia	1.29 (0.83, 2.01)	1.76 (1.15, 2.68)	0.03
Diabetes mellitus	0.66 (0.41, 1.06)	0.62 (0.40, 0.96)	0.04
Stroke	1.01 (0.61, 1.67)	0.52 (0.32, 0.85)	0.03
Family History of Stroke	4.12 (1.80, 9.46)	1.25 (0.40, 3.86)	0.004
Initial NIH Stroke Scale Score			
0-5	1.77 (0.63, 5.01)	2.44 (1.07, 5.57)	0.28
6-15	1.32 (0.50, 3.51)	1.83 (0.85, 3.97)	
> 15	Reference	Reference	
Intra-arterial alteplase or thrombectomy at this hospital	4.49 (2.00, 10.08)	2.77 (1.38, 5.59)	0.0002
Anti-depressant not prescribed at discharge	0.73 (0.38, 1.42)	0.50 (0.25, 0.98)	0.11
Ambulatory status at discharge			0.10
Ambulate independently with or without device	4.16 (1.20, 14.39)	1.03 (0.41, 2.60)	
Ambulate with assistance from person	3.96 (1.21, 12.98)	1.54 (0.67, 3.52)	
Unable to ambulate	Reference	Reference	
Discharge disposition			
Acute Care Facility	1.63 (0.30, 8.79)	0.61 (0.07, 5.60)	0.11
Other Health Care Facility	0.65 (0.33, 1.29)	0.47 (0.26, 0.85)	
Home	Reference	Reference	

patient subset have been demonstrated in other specialties[11-13] and are similar to those previously described. Interviewing underserved patients has identified significant barriers including lack of patient-provider trust and shared decision-making, social determinants and limited care coordination within the community.[14] A specific approach for this patient subset is necessary to help overcome barriers and improve follow-up in this patient population.

Patients who were able to ambulate independently or with assistance at discharge were more likely to follow-up in person. We did find that patients unable to ambulate at discharge were more than twice as likely to follow-up with telemedicine as compared with in-person visit suggesting that this form of follow-up may be preferred in this subgroup.

Limitations of this study included the gradual implementation of telemedicine rather than a strict start date,

which may influence our results on the impact of telemedicine on 90-day patient follow-up. The COVID-19 pandemic negatively impacted outpatient follow-up in various medical specialties due to fear of infection[15,16] which may have impacted the findings of this study.

Despite the implementation of telemedicine during the COVID-19 pandemic, most ischemic stroke patients did not follow-up in a stroke specialty clinic within 90 days of discharge. Though a higher proportion of patients followed up with telemedicine than in-person, telemedicine itself is not a panacea for patient access. As our study shows, other factors including insurance status, distance of the treating hospital from the clinic site, stroke severity, and non-home discharge affect the rate of follow up. These factors are likely related to financial, transportation and logistical issues that require considerable attention to achieve a desired post-stroke follow up rate and should be carefully considered in stroke populations. Incremental improvement in post-stroke follow up may require interventions that address each of these factors, including ensuring the presence of caregivers to act as a mediator for telemedicine consultations, ensuring appropriate coordination of follow up at all sites of hospital discharge, and facilitating financial models to care for patients without insurance to receive ongoing care. Further study is warranted to see if reducing barriers can continue to increase stroke follow up Table 2.

Declaration of Competing Interest

There were no unusual circumstances surrounding the research, nor were there deviations from standard procedures or format. There is no funding or financial support to disclose.

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