# Falling stroke rates during COVID-19 pandemic at a comprehensive stroke center

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*Introduction:* Although there is evidence to suggest a high rate of cerebrovascular complications in patients with SARS-CoV-2 infection, anecdotal reports indicate a falling rate of new ischemic stroke diagnoses. We conducted an exploratory single-center analysis to estimate the change in number of new stroke diagnoses in our region, and evaluate the proximate reasons for this change during the COVID-19 pandemic at a tertiary care center in New Jersey. *Patients and methods:* A Comprehensive Stroke Center prospective cohort was retrospectively analyzed for the number of stroke admissions, demographic features, and short-term outcomes 5 months prior to 3/1/2020 (pre-COVID-19), and in the 6 weeks that followed (COVID-19 period). The primary outcome was the number of new acute stroke diagnoses before and during the COVID-19 period, as well as the potential reasons for a decline in the number of new diagnoses. *Results:* Of the 328 included patients, 53 (16%) presented in the COVID-19 period. There was a mean fall of 38% in new stroke diagnoses (mean 1.13/day [SD 1.07] from 1.82/day [SD 1.38], $p < 0.01$), which was related to a 59% decline in the number of daily transfers from referral centers ($p < 0.01$), 25% fewer telestroke consultations ($p = 0.08$), and 55% fewer patients presenting directly to our institution by private vehicle ($p < 0.01$) and 29% fewer patients through emergency services ($p = 0.09$). There was no significant change in the monthly number of strokes due to large vessel occlusion (LVO), however the proportion of new LVOs nearly doubled in the COVID-19 period (38% vs. 21%, $p = 0.01$). *Conclusions:* The observations at our tertiary care center corroborate anecdotal reports that the number of new stroke diagnoses is falling, which seems related to a smaller proportion of patients seeking healthcare services for milder symptoms. These preliminary data warrant validation in larger, multi-center studies.

**Keywords:** Epidemiology—Ischemic Stroke—Incidence—COVID-19—Coronavirus

## Background

The novel human coronavirus, severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), began in Wuhan, China in December of 2019 and has led to a pandemic, accounting for more than 2.4 million worldwide infections and more than 160,000 deaths (as of April 20, 2020).[1,2]

Because of the rapid spread of the virus over the preceding 4 months, and the severity of the illness caused by it, public health officials have driven sweeping reforms to stem further dissemination of SARS-CoV-2. Perhaps as a consequence of these efforts, and in part due to social anxiety regarding infection and contact with healthcare providers,[3] there are likely to be a number of unforeseeable epidemiologic aftereffects. As people accommodate to social distancing recommendations by public health and government officials, avoid healthcare institutions and clinics—or resort to (sometimes limited) telemedical evaluations, we will likely observe a shift in the epidemiology of

stroke and other medical conditions.[4] Milder symptoms of an acute cerebrovascular event—which could have historically prompted patients to seek medical attention, receive acute treatment and aggressive secondary stroke prevention—may now be minimized to the point that these patients will not present to the emergency room or notify their primary care physician. Because of this psychosocial consequence of a pandemic, it is possible that the reported incidence rate of acute ischemic stroke may decline during the COVID-19 pandemic, while the reported incidence rate of more severe cerebrovascular events (e.g., strokes due to large vessel occlusion) will remain stable, as these severe symptoms cannot be ignored by patients or family members.

In the present investigation, we sought to evaluate the impact of the current COVID-19 pandemic on the number, etiologies, and severity of new acute ischemic stroke diagnoses (according to the National Institutes of Health Stroke Scale [NIHSS] and the proportion of patients with acute large vessel occlusion [LVO]) in our tertiary care center. We hypothesized that the number of new acute ischemic strokes will fall, while the severity of ischemic stroke will be relatively greater in the six weeks of our COVID-19 response, when compared to the pre-COVID-19 period.

## Materials and methods

### Study design and participants

We conducted a retrospective analysis of a prospective observational cohort of consecutive adults ≥18 years of age admitted to Cooper University Hospital (CUH) with a final diagnosis of acute ischemic stroke from October 1, 2019 to April 15, 2020. CUH is a 574-bed, tertiary care, Comprehensive Stroke Center in southern New Jersey that serves as a referral base for 5 Primary Stroke Centers in the region, for whom CUH offers formal telestroke services. Acute ischemic stroke was diagnosed clinically by a vascular neurologist as long as symptom onset occurred in the preceding two weeks (or onset was unknown), or if there was radiographic evidence of acute infarction on unenhanced computed tomography (CT) or diffusion-weighted magnetic resonance imaging (DWI-MRI). Patients were compared between two treatment periods: (1) pre-COVID-19, which included patients admitted on dates between October 1, 2019 to February 29, 2020; and (2) COVID-19, which included patients admitted on dates between March 1, 2020 to April 15, 2020. March 1, 2020 was selected as the start date of the COVID-19 period as it was the date of the first New Jersey resident to develop COVID-19 symptoms, with serologic confirmation of SARS-CoV-2. (By March 20, 2020, the state of New Jersey was placed into lockdown by government authorities, however social distancing had become encouraged long before this.) To be included in this observational cohort, all patients underwent a non-contrast head CT to evaluate for intracranial hemorrhage or other structural brain lesions that could explain the patient's neurological symptoms. Magnetic resonance imaging (MRI) was not required.

### Data collection

The baseline demographics, National Institutes of Health Stroke Scale (NIHSS) scores, use of MRI, presence of a proximal LVO, timing and use of thrombolytic and endovascular treatment, and discharge disposition were collected for all included patients. The total number of brain MRI scans performed on inpatients treated at our center, as well as the number of brain MRI scans performed for the primary indication of acute stroke ("stroke protocol MRI") were abstracted from our institutional Picture Archiving and Communication System. Stroke etiology was classified according to the modified Trial of Org 10172 Acute Stroke Trial criteria[5]—inclusive of strokes due to multiple possible etiologies and strokes of unknown etiology. LVO was defined as the radiographic confirmation of an arterial occlusion in the intracranial internal carotid artery (ICA), proximal segment of the middle cerebral artery (M1), middle cerebral artery segments (M2), or basilar occlusion. A "cortical sign" was defined by the National Institutes of Health Stroke Scale (NIHSS) subscores if any of the following points were allocated on admission: 1-2 points for items 1b, 1c, best gaze, and extinction; 1−3 points for visual field; and 2-3 points for language. (A liberal definition of cortical sign was chosen to optimize sensitivity.) Data was captured using a HIPAA-compliant, web-based platform (RED-Cap), as described previously.[6]

### Statistical analysis

Descriptive statistics were used to summarize continuous and categorical variables. Normality of continuous data was assessed histographically and confirmed using the Shapiro-Wilk test. Continuous variables were reported as medians with interquartile range, or means with standard deviation. Categorical variables were reported as proportions. Between-group comparisons for categorical data were made using Chi-square, or Fisher's exact test when contingency table cell counts were less than five. Between-group comparisons for non-normally distributed continuous data were made using Wilcoxon rank-sum tests, or unpaired t-test for normally distributed continuous data. Although the counts for daily stroke admissions, daily transfers, and daily telestroke consultations were non-normally distributed, means (with standard deviation) have been provided in order to illustrate relative changes between study periods because event rates were low. The immediate test of proportions was used to evaluate for differences between the proportion of daily LVOs diagnosed between periods.

The primary outcome of this exploratory study was the daily number of new acute stroke diagnoses in our tertiary care referral center. Secondary outcomes included stroke severity (according to NIHSS and the number and proportion of patients diagnosed with an acute LVO), the distribution of stroke etiologies, time from evaluation to imaging and treatment, use of MRI, length of hospital stay, and discharge disposition. Linear regression was used to estimate the association between the COVID-19 period and length of hospital stay, while logistic regression was used to estimate the association between the COVID-19 period and categorical outcome variables. These models were adjusted for age, baseline NIHSS, and presence of LVO. An adjusted logistic regression model was also used to estimate the odds of LVO during the COVID-19 period, adjusting for age and NIHSS. For the secondary outcome of in-hospital mortality, logistic regression was used to estimate the odds of this outcome based on the COVID-19 period, and this was adjusted for age, NIHSS, and LVO. "Transition to comfort measures" was deliberately excluded from this model as it perfectly predicted in-hospital mortality and hospice care. All tests were performed at the two-sided level with an alpha of 0.05, using STATA 15.0 (College Station, TX). P-values are provided for conventional purposes and should be interpreted with caution due to the exploratory nature of this analysis. No adjustments were made for multiple comparisons. Missing data were not imputed.

This study was approved by the local institutional review board. Data will be made available upon reasonable request of the corresponding author.

## Results

Of the 328 patients included in this observational cohort, the median age was 69 (IQR 59-79), and 136 (42%) were female. Fifty-three patients (16% of the cohort) presented in the COVID-19 period.

When compared to stroke patients evaluated in the pre-COVID-19 period, those evaluated during COVID-19 at our center had no significant differences with respect to age, sex, race, vascular risk factors, or stroke severity (Table 1). Of the NIHSS subscore items, only item 1b was scored more highly among patients evaluated during the COVID-19 period (median 1 [IQR 0-2] vs. 0 [IQR 0-2], $p$=0.04). However, when cortical signs were grouped, the presence of any cortical sign was more common among patients who presented during the COVID-19 period when compared to the months prior (68% vs. 53%, $p$=0.04).

The primary outcome of new daily stroke diagnoses was significantly lower during the COVID-19 period than the pre-COVID-19 period (median 1/day [IQR 0-2] vs. 2/day [IQR 1-3], $p$<0.01; Table 2), with a mean fall of 38% during the COVID-19 period (mean 1.13/day [SD 1.07] vs. 1.82/day [SD 1.38], $p$<0.01). There was also a 59% decrease in the mean number of daily transfers from outside hospitals

($p$<0.01) and a non-significant 25% decrease in the mean number of daily telestroke consultation requests ($p$=0.08). Among patients who were admitted directly through our emergency department, there was a significant 55% decrement in the number of patients presenting via private vehicle ($p$<0.01). and a non-significant 29% decrement in the number of patients presenting via emergency medical services ($p$=0.09; Table 1).

While patients evaluated during the COVID-19 period were at a greater odds of presenting with cortical signs (OR 1.89, 95%CI 1.02-3.54, $p$=0.04), this was driven by the higher odds of these patients harboring a LVO (OR 2.22, 95%CI 1.19-4.15, $p$=0.01). The higher odds of LVO during the COVID-19 period remained significant after adjustment for age and stroke severity (aOR 2.06, 95%CI 1.02-4.16, $p$=0.04). There was no appreciable difference in the number of total monthly LVO cases (mean 0.39/day pre-COVID-19 vs. 0.43/day, $p$=0.61) although the proportion of patients with LVO grew (Table 1). There was also no significant difference in the distribution of stroke etiologies between the two periods ($p$=0.98; Table 2). Irrespective of the final diagnosis, fewer brain MRIs were performed during the COVID-19 period when compared to pre-COVID-19 (mean 148/mo. vs. 349/mo., $p$<0.01), and non-significantly fewer stroke protocol MRIs performed every month (26 vs. 56, $p$=0.08). Among patients with a final diagnosis of stroke, MRI was also utilized less frequently during the COVID-19 period versus pre-COVID-19 (55% vs. 88%, $p$<0.01).

There was no significant delay from the time patients were last known well to ED arrival, arrival to computed tomography scan or to thrombolysis. Patients treated during COVID-19 had a shorter hospital length of stay when compared to patients admitted during the pre-COVID-19 period ($\beta$=-2.91, 95%CI -5.83 − 0.02, $p$=0.05), and this remained significant after adjustment for age, NIHSS, and presence of LVO (adjusted $\beta$=-3.39, 95%CI -6.10 − -0.68, $p$=0.01). Patients admitted during the COVID-19 period were at a greater odds of dying during their hospitalization in unadjusted regression (OR 3.65, 95%CI 1.52-8.72, $p$<0.01), however this effect became non-significant after adjustment for age, NIHSS, and LVO (aOR 2.16, 95%CI 0.80-5.86, $p$=0.13). Only 9 patients had available polymerase chain reaction test results for the SARS-CoV-2 virus during the COVID-19 period, and 1 tested positive (who expired during their hospitalization).

## Discussion

In this single-center, prospective observational study, we observed a significant decline in the daily number of new acute stroke diagnoses at our tertiary care center in the six weeks of the COVID-19 pandemic when compared to the pre-COVID-19 period. There was no change in the monthly number of patients harboring an acute LVO, although the proportion of patients with an LVO was significantly

**Table 1.** *Demographics.*

|  | Pre-COVID-19 period | COVID-19 period | P-value |
|---|---|---|---|
| Age, mean (+/- SD) | 68 (14) | 68 (15) | 0.91 |
| Sex, no. females (%) | 113 (41%) | 23 (43%) | 0.76 |
| Race, no. (%) |  |  | 0.90 |
|     White | 152/271 (56%) | 30/53 (57%) |  |
|     Black | 76/271 (28%) | 13/53 (25%) |  |
|     Asian | 6/271 (2%) | 1/53 (2%) |  |
|     Other/Unknown | 42/271 (15%) | 9/53 (17%) |  |
| Hispanic, no. (%) | 32/274 (12%) | 6/53 (11%) | 0.37 |
| Transfers from outside hospital, no. (%) | 120 (44%) | 16 (30%) | 0.07 |
|     Transfers, median per day (IQR) | 1 (0-1) | 0 (0-1) | <0.01 |
|     Transfers, mean per day (+/- SD) | 0.80 (0.89) | 0.33 (0.60) | <0.01 |
|     Arrival mode*, no. (%) |  |  |  |
|       Private vehicle/walk-in | 84/155 (54%) | 11/37 (30%) | <0.01 |
|       EMS | 71/155 (45%) | 26/37 (70%) | <0.01 |
|     Arrival mode[†], median per day (IQR) |  |  |  |
|       Private vehicle/walk-in | 0 (0-1) | 0 (0-0) | <0.01 |
|       EMS | 1 (0-2) | 1 (0-2) | 0.09 |
|     Arrival mode[†], mean per day (+/- SD) |  |  |  |
|       Private vehicle/walk-in | 0.55 (0.75) | 0.24 (0.57) | <0.01 |
|       EMS | 1.25 (1.18) | 0.89 (0.90) | <0.01 |
| Telestroke consultations, median per day (IQR) | 2 (1-4) | 1 (0-3) | 0.08 |
| Telestroke consultations, mean per day (+/- SD) | 2.36 (1.88) | 1.76 (1.63) | 0.08 |
| In-hospital stroke, no. (%) | 44 (16%) | 9 (17%) | 0.86 |
| Past medical history, no. (%) |  |  |  |
|     Prior stroke | 75/274 (27%) | 14 (26%) | 0.90 |
|     Atrial fibrillation | 53/273 (19%) | 8/53 (15%) | 0.63 |
|     Hypertension | 233 (85%) | 42 (79%) | 0.32 |
|     Diabetes mellitus | 116 (42%) | 23 (43%) | 0.87 |
|     Dyslipidemia | 170 (62%) | 33 (62%) | 0.95 |
|     Coronary artery disease | 65/274 (24%) | 12 (23%) | 0.90 |
| NIHSS at presentation, median (IQR) | 5 (2-13) | 8 (2-13) | 0.26 |
| ASPECTS score[‡], median (IQR) | 10 (9-10) | 10 (10-10) | 0.40 |
|     ASPECTS score[‡] among LVO patients, median (IQR) | 6 (2-10) | 10 (10-10) | 0.32 |
| LVO, no. (%) | 59 (21%) | 20 (38%) | 0.01 |
| Total no. COVID-19+ stroke patients[§] | n/a | 1/9 | n/a |

COVID denotes coronavirus 2019 disease, SD standard deviation, IQR interquartile range, EMS emergency medical services, NIHSS National Institutes of Health Stroke Scale, ASPECTS Alberta Stroke Program Early Computed Tomography Scale, and LVO large vessel occlusion.

*Arrival mode calculated for patients who presented directly to Cooper University Hospital.

[†]Mean and median daily arrivals calculated for patients who presented directly to Cooper University Hospital (non-transfers).

[‡]ASPECTS scores included only for anterior circulation infarctions.

[§]"COVID+" denotes serologically confirmed cases of SARS-CoV-2 among stroke patients evaluated at CUH. This number is not applicable to the pre-COVID-19 period due to assay unavailability.

greater during the COVID-19 period. We do not believe the local incidence rate of acute stroke is falling. This perceived fall in new stroke diagnoses may be related to several social and healthcare factors and parallels other observations in the vascular literature[4] and the media.[7]

Perhaps most importantly, the patients evaluated during the COVID-19 period had more severe illness. While there was no statistically significant difference in NIHSS between patients evaluated during the two periods, the NIHSS is a limited research instrument that does not perfectly capture stroke severity,[8] neurologic improvement,[9] or final infarct volume.[10] Patients with a severe aphasia, vision loss, or

dominant hand weakness may have significant disability as a consequence of their stroke, but have relatively low NIHSS.[11] These cortical signs correlate with acute LVO—the natural history of which is almost always poorer than non-LVO strokes.[12] Furthermore, the median baseline NIHSS, the prevalence of LVO, and the adoption of comfort measures were all higher during the COVID-19 period. The high in-hospital mortality rate among patients evaluated during the COVID-19 period also speaks to the severity of the illness experienced by patients during this period. The observed in-hospital mortality rate of 21% after a median length of stay of only 2.5 days would be higher

**Table 2.** *Diagnostic results and outcomes.*

|  | Pre-COVID-19 period | COVID-19 period | P-value |
|---|---|---|---|
| Daily stroke admissions, mean (+/- SD) | 1.82 (1.38) | 1.13 (1.07) | <0.01 |
| Daily stroke admission, median (IQR) | 2 (1-3) | 1 (0-2) | <0.01 |
| Stroke etiology, no. (%) |  |  | 0.98 |
|   Extracranial atherosclerosis | 21 (8%) | 5 (9%) |  |
|   Intracranial atherosclerosis | 27 (10%) | 7 (13%) |  |
|   Small-vessel occlusion | 24 (9%) | 4 (8%) |  |
|   Cardioembolism | 61 (22%) | 11 (21%) |  |
|   Other determined etiology | 43 (16%) | 9 (17%) |  |
|   Cryptogenic—Multiple etiologies possible | 32 (12%) | 6 (11%) |  |
|   Cryptogenic—Unknown | 67 (24%) | 11 (21%) |  |
| Time course, median min. (IQR) |  |  |  |
|   Time from LKW to ED arrival | 412 (57-1318) | 517 (164-1072) | 0.63 |
|   Time from ED arrival to Initial CT | 35 (19-211) | 26 (16-141) | 0.10 |
|   Time from ED arrival to IV tPA bolus* | 39 (26-52) | 39 (34-82) | 0.46 |
| MR Imaging, mean no./month (SD) |  |  |  |
|   Any MRI brain[†] (all CUH inpatients) | 349 (28) | 148 (122) | 0.01 |
|   Stroke protocol MRI brain[†] (all CUH inpatients) | 56 (12) | 26 (28) | 0.08 |
|   Any MRI brain (among stroke patients) | 241 (88%) | 29 (55%) | <0.01 |
| Treatment, no. (%) |  |  |  |
|   Intravenous thrombolysis | 33 (12%) | 3 (6%) | 0.23 |
|   Endovascular Thrombectomy | 50 (88%) | 18 (90%) | 0.72 |
| Length of hospital stay, median days (IQR) | 4 (2-8) | 2.5 (2-7) | 0.04 |
| Use of comfort measures, no. (%) | 37 (13%) | 9 (21%) | 0.20 |
| Discharge disposition, no. (%) |  |  | <0.01 |
|   Home | 92 (34%) | 21 (50%) |  |
|   Acute inpatient rehab | 100 (37%) | 8 (19%) |  |
|   Subacute inpatient rehab | 36 (13%) | 3 (7%) |  |
|   Hospice | 22 (8%) | 1 (2%) |  |
|   Other | 3 (1%) | 0 (0%) |  |
|   Expired | 19 (7%) | 9 (21%) |  |

COVID denotes coronavirus 2019 disease, SD standard deviation, IQR interquartile range, LKW last known well, ED emergency department, CT computed tomography, IV tPA intravenous tissue plasminogen activator, MR magnetic resonance, MRI magnetic resonance imaging, CUH Cooper University Hospital.

*Time to IV tPA bolus calculated among patients who received intravenous thrombolysis.

[†]Counts of MRI brain refer to the total number of inpatient brain MRIs performed per month during the study period. Imaging counts were multiplied by two for the month of April given study termination on April 15.

than what is predicted from the 14-25% 90-day mortality rates observed in the thrombectomy arms from the DAWN[13] and DEFUSE-3[14] clinical trials, and certainly higher than the 14-15% 90-day mortality rate observed from multicenter observational data including patients treated in randomized trials[15] and in routine clinical practice.[16] For these reasons, we believe stroke severity was greater during the COVID-19 period than the months preceding it. At this point, we do not have 90-day mortality or functional outcome data on patients treated during the COVID-19 period, but we will be exploring this in future investigations and as part of an ongoing multicenter effort.

The high mortality rate does not appear to be an independent effect of the COVID-19 period, however, it may be that patients with less severe symptoms and fewer (or no) cortical signs might feel less motivated to seek medical assistance for a new neurologic concern. According to our data regarding transportation method, there was a significantly smaller number of patients who presented to the hospital via EMS,

while there was a trend toward a lower usage of private vehicles (or "walk-in's"). These results are suggestive that people may be disinclined from calling "9-1-1" (especially for milder symptoms); and, more importantly, a significantly smaller number of patients are coming in on their own to seek neurologic attention. This observation may be a social consequence of many factors, including greater social isolation as community dwellers adhere to public health recommendations and/or avoid seeking healthcare services due to employment concerns and loss of insurance.

Many patients with stroke often fail to recognize mild symptoms, such as a visual field disturbance, facial droop, or neglected extremity. Symptoms of stroke are frequently noticed by another family member, friend, or community member before they are recognized in the patients themselves, which emphasizes the importance of patient education of stroke warning signs and symptoms. This stroke education should not end at the level of the patient or community, but should expand to all healthcare providers,

especially primary care and urgent care providers. Patients may be presenting more frequently to urgent care facilites to avoid emergency department interactions, and this may also account for the decreased number of new stroke diagnoses during the current COVID-19 period.

Minor neurologic symptoms are common,[17] and if rapid and appropriate outpatient diagnostic testing and treatment can be arranged—with close follow-up—many patients could be safely managed in the outpatient setting. In this way, non-disabled stroke patients may reduce their exposure to SARS-CoV-2, limit the consumption of emergency hospital resources, and potentially lessen the cost of their healthcare. Such a paradigm shift in the care of mild stroke would be consistent with recommendations from the Centers for Disease Control and Prevention (CDC), which has promoted the use of telehealth to mitigate the transmission of SARS-CoV-2.[18]

Guidelines exist for the acute management of stroke patients with mild symptoms and no LVO,[19] and for the care of patients during the COVID-19 pandemic.[20] Even in patients with a minor stroke or TIA, the risk of recurrent stroke, myocardial infarction, or death is as high as 9% in sub-optimally treated patients.[21] While it is critical to expedite the evaluation of patients with acute stroke in order to determine the proximate cause of infarction, centers may be increasingly reliant on expediting outpatient diagnostic testing and rapid telehealth follow-up visits. This paradigm shift may be effective for the care of patients during the COVID-19 pandemic, and should be explored in population-based studies.

One other factor that could have contributed (albeit to a lesser degree) to the lower stroke rate is the reduction in utilization of MRI—with potentially fewer silent infarcts identified during the COVID-19 period. However, for patients with normal CT imaging for whom CUH providers have a reasonable suspicion of stroke, our team will frequently repeat a head CT after 12-24 hours if MRI is not readily available (or when MRI use becomes restricted in order to prevent contamination). Therefore, at least for clinically-relevant infarcts (e.g., non-silent infarcts), we do not believe the lower use of MRI significantly contributes to the fall in new strokes.

One final, but important observation is that patients treated during the COVID-19 period had no significant delay from last known well to arrival, or from arrival to imaging or treatment. If anything, there was a non-significant 9-minute improvement in the median time to thrombolysis among patients treated with IV tPA during the COVID-19 period despite the increase in precautionary measures that have been implemented to protect healthcare workers and prevent facility contamination (26 vs. 35 min, $p$=0.1). While we hope to maintain this degree of workflow efficacy, it is possible that patients with stroke may present later in the course of their illness, and may experience longer delays from arrival to imaging or treatment. These results warrant validation in larger, multicenter studies, and should

encourage centers to emphasize safe and effective throughput of patients with critical conditions, including stroke.

It is important to note that while we, and others,[7,22] have observed a fall in the number of new acute stroke diagnoses during the COVID-19 pandemic, there is increasing evidence that SARS-CoV-2 leads to significant systemic inflammation and an increased risk of thrombotic events.[23–26] A recent case series of 5 young, healthy patients and acute large vessel occlusion highlighted extraordinary elevations in serum D-dimer levels in association with SARS-CoV-2 infection.[27] While expert recommendations for the management of acute stroke[20] and large vessel occlusion[28] are being updated to adapt to the COVID-19 pandemic, there remains uncertainty whether patients with COVID-19 ought to be prophylactically treated with antithrombotics to reduce the risk of vascular events.[26] Additional studies are needed to clarify how serum markers of inflammation and coagulopathy predict clinical outcomes, or whether they should prompt initiation of thrombotic prophylaxis in these patients.

*Limitations*

This was a single center observational study of a brief period during the early phase of the COVID-19 pandemic, and therefore may not be generalizable to other centers in other regions of the country and may not necessarily indicate more persistent changes in local stroke epidemiology. The small sample size raises the possibility of type I error. It is possible that more severe neurologic deficits, as captured by the NIHSS, may be more common among patients with stroke in the era of COVID-19. However, our single-center experience and preliminary results may be underpowered to detect these and other significant differences. It would have been more appropriate to compare identical periods in 2019 (e.g., 3/1/2019 − 4/15/2019) to the COVID-19 period in 2020, however we chose the immediately preceding months as the 'control' period due to a more than doubled staffing of vascular neurologists and growing telestroke referral base by mid-2019. By the fall of 2019, we had already witnessed an increase in our center's acute stroke volume, therefore comparing identical weeks in 2019 and 2020 may have falsely underestimated the anticipated stroke rate from 3/1/2020 − 4/15/2020. Selecting March 1, 2020 as the start date of the COVID-19 period was also somewhat arbitrary. However, it was selected based on emerging public health data that month, and allowed for data to be analyzed by month as well as by day. A post hoc analysis of data stratified by March 20, 2020 was also performed with similar results as shown in Tables 1 and 2, with notable exceptions being a loss of significance in the difference of new stroke diagnoses between periods. That said, higher NIHSS and the presence of LVO remained more common among patients admitted after 3/20/2020 (median NIHSS 9 vs. 5, $p$=0.06; 46% LVO vs. 22%, $p$<0.01). Due to the early release of these results, we also

lack long-term outcome data regarding functional disability and readmission rates—which may be higher during the COVID-19 period due to a higher proportion of discharges to home. These results should be interpreted with caution until they are validated by larger scale, multi-institutional studies, which are ongoing.

## Conclusions

As the neurological sequelae of COVID-19 are being increasingly recognized,[29,30] we must not ignore the social impact of a pandemic on the care of patients with acute stroke. In this prospective observational cohort, we observed a significant decline in the number of new acute stroke diagnoses at our tertiary care, Comprehensive Stroke Center in southern New Jersey. New Jersey is second only to New York as the state with the highest number of confirmed COVID-19 cases[31]—with more than 85,000 cases as of April 20, 2020—therefore our results may not be presently generalizable to institutions where SARS-CoV-2 is ubiquitous. However, these findings may be quickly observed at other institutions as more and more cases of COVID-19 are diagnosed and patients learn to avoid hospital systems. Unsurprisingly, the number of patients with LVO did not appreciably change during the COVID-19 period when compared to the pre-COVID-19 period. This supports our hypothesis that patients with milder symptoms may be intentionally avoidant of seeking treatment at healthcare facilities. This effect may manifest both in the number of calls to emergency medical services, and in the number of patients who present to the ED via private vehicles. To the authors' knowledge, this study is the first to confirm anecdotal reports[7] that stroke admission rates may decline because of the SARS-CoV-2 pandemic. Additionally, with the focus of our healthcare system shifted towards identifying patients with SARS-CoV-2 and preserving healthcare resources, patients with mild stroke symptoms will possibly be discharged prematurely without a complete stroke evaluation or a secondary stroke prevention strategy. Furthermore, the utilization of DWI-MRI is decreasing, therefore patients have to have more severe focal neurological deficits to be diagnosed with an acute ischemic stroke, when head CT is the sole imaging modality being used. Consequently, this has the potential to impact estimates of stroke-related disability. Larger studies representing multiple populations are underway and may better elucidate the clinical implications of missed stroke diagnoses and other social consequences of the SARS-CoV-2 pandemic.

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### Disclosures

None.

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