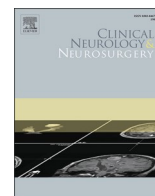




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## Trends in interventional stroke device utilization during the COVID-19 pandemic

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### ABSTRACT

**Objectives:** The collateral effect of the COVID-19 pandemic on interventional stroke care is not well described. We studied this effect by utilizing stroke device sales data as markers of interventional stroke case volume in the United States.

**Methods:** Using a real-time healthcare device sales registry, this observational study examined trends in the sales of thrombectomy devices and cerebral aneurysm coiling from the same 945 reporting hospitals in the U.S. between January 22 and June 31, 2020, and for the same months in 2018 and 2019 to allow for comparison. We simultaneously reviewed daily reports of new COVID-19 cases. The strength of association between the cumulative incidence of COVID-19 and procedural device sales was measured using Spearman rank correlation coefficient (CC).

**Results:** Device sales decreased for thrombectomy (− 3.7%) and cerebral aneurysm coiling (− 8.5%) when comparing 2019–2020. In 2020, thrombectomy device sales were negatively associated with the cumulative incidence of COVID-19 (CC − 0.56,  $p < 0.0001$ ), with stronger negative correlation during April (CC − 0.97,  $p < 0.0001$ ). The same negative correlation was observed with aneurysm treatment devices (CC − 0.60,  $p < 0.001$ ), with stronger correlation in April (CC − 0.97,  $p < 0.0001$ ).

**Conclusions:** The decline in sales of stroke interventional equipment underscores a decline in associated case volumes. Future pandemic responses should consider strategies to mitigate such negative collateral effects.

## 1. Introduction

Studies have revealed a negative collateral effect of the COVID-19 pandemic on emergent stroke and cardiovascular care in the U.S. as well as globally [1–4]. As the COVID-19 pandemic continues, there is a call to understand the magnitude of such collateral effects in the U.S. and thus better guide future responses in minimizing such effects [2,4]. While the collateral effect of the COVID-19 pandemic on stroke has been reported at the regional level in the U.S., we aimed to study this effect in real time at the national level by utilizing interventional stroke device sales data as a marker of interventional stroke case volumes.

## 2. Materials and methods

### 2.1. Data registry

Using a device sales data registry from the Decision Resources Group, a healthcare research and consulting company, we examined trends in the sales of cerebrovascular thrombectomy and cerebral aneurysm devices from the same 945 reporting hospitals in the U.S. between January 22, 2020 (date of first coronavirus case in the U.S.) and June 31, 2020. This device sales data registry contains all purchase order transactions from each reporting hospital's purchase order system. As such, data are

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collected directly from each hospital’s purchase order record. The full list of devices included in the analysis are found in the Online Supplement. Trends in device sales in 2020 were compared with trends during the same periods in 2019 and 2018. Geographic regions were defined in accordance with the U.S. Census Bureau—South, Midwest, West, and Northeast. We simultaneously reviewed daily reports of new COVID-19 cases based on positive results of SARS-CoV-2 nasopharyngeal swab testing (Centers for Disease Control), and the incidence of COVID-19 was represented as the number of COVID-19 cases per 100,000 persons.

### 2.2. Statistical analysis

Device sales per month were extrapolated as a continuous variable by dividing the difference in device sales tallied at the end of each month by the number of days in that month. We computed the Spearman rank correlation coefficient (R) to measure the strength of the correlation between the cumulative incidence of COVID-19 and procedural device sales in the U.S. and for each geographic region. The proportion (%) of device sales for each device type per month was calculated by dividing the number of devices sold in a month by the total sales of that device during the study period. The COVID-19 case rate and proportion of device sales were plotted together by region. Analyses were performed using RStudio version 1.1.456 (<https://rstudio.com>).

## 3. Results

### 3.1. Device sales compared to 2019

The percent changes in device sales from 2019 to 2020 for thrombectomy and cerebral aneurysm devices were - 3.7% and - 8.5%, respectively. The percent changes in device sales from 2018 to 2019 for thrombectomy and cerebral aneurysm devices, meanwhile, were + 30.0% and + 3.7%, respectively. In April 2020, there was a sharp decline in device sales: - 5% for thrombectomy device sales and - 5.8% for aneurysm device sales. This decline in sales reversed course with increased sales during May 2020 for aneurysm devices and during June 2020 for all devices.

During the study period in 2020, a total of 2,934,455 cases of COVID-19 were reported in the U.S. During the same period, there were a total of 11,132 thrombectomy device sales and 27,479 aneurysm device sales (Table 1). During the corresponding period in 2019, there were 11,562 thrombectomy device sales and 30,027 aneurysm device sales. As such, the percent changes in device sales from 2019 to 2020 for thrombectomy and aneurysm devices were - 3.7% and - 8.5%, respectively. These data are especially notable in contrast to the increase in thrombectomy and aneurysm device sales from 2018 to 2019. When looking at device sales by region, the Midwest had the greatest magnitude of decline in thrombectomy device sales, with a percent change of - 12.2% from 2019 to 2020. Notably, the West had the greatest decline in aneurysm device sales, with a percent change of - 11.3% from 2019 to 2020.

### 3.2. Device sales and COVID-19 incidence

The proportion of thrombectomy device sales by month in 2020 was

**Table 1**

Numbers of COVID-19 cases reported in 2020 (January through May) and numbers of thrombectomy and aneurysm device sales during the same period in 2020, 2019, and 2018.

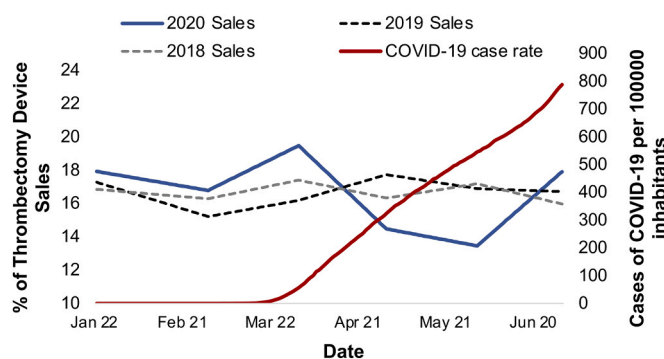
Region	Cases of COVID-19 2020	Thrombectomy device sales 2020	Thrombectomy device sales 2019	Thrombectomy device sales 2018	Percent change 2019–20	Percent change 2018–19	Aneurysm device sales 2020	Aneurysm device sales 2019	Aneurysm device sales 2018	Percent change 2019–20	Percent change 2018–19
South	774,525	4771	4859	3655	- 1.8	32.9	11,669	12,880	11,477	- 9.4	12.2
Midwest	691,475	1706	1944	1413	- 12.2	37.6	4524	4975	5323	- 9.1	- 6.5
West	413,900	3279	3346	2690	- 2.0	24.4	8148	9186	9081	- 11.3	1.2
Northeast	1,054,555	1376	1413	1135	- 2.6	24.5	3138	2986	3079	5.1	- 3.0
Total	2,934,455	11,132	11,562	8893	- 3.7	30.0	27,479	30,027	28,960	- 8.5	3.7

strongly and negatively associated with the cumulative incidence of COVID-19 in the U.S. overall (Spearman rank correlation coefficient (CC), - 0.56,  $p < 0.0001$ ), with even stronger correlation during April 2020 (CC - 0.97,  $p < 0.0001$ ) (Fig. 1). Examining these trends by region revealed a significantly negative association between thrombectomy device sales and the incidence of COVID-19 in the South (CC - 0.59,  $p < 0.001$ ), Midwest (CC - 0.19,  $p = 0.04$ ), West (CC - 0.66,  $p < 0.0001$ ), and Northeast (CC - 0.75,  $p < 0.0001$ ), with the strongest association being in the Northeast. For all regions, the greatest decline in the rate of thrombectomy device sales in 2020 was seen in April.

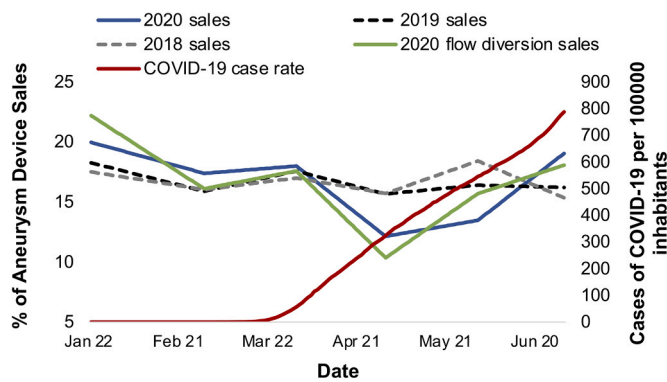
There was a strongly negative association between aneurysm device sales in 2020 and COVID-19 incidence in the U.S. overall (CC - 0.60,  $p < 0.001$ ), with even stronger correlation in April (CC - 0.97,  $p < 0.0001$ ) (Fig. 2). This was also seen in each region individually. Examining these trends by region revealed a significantly negative association between aneurysm device sales and the incidence of COVID-19 in the South (CC - 0.54,  $p < 0.001$ ), Midwest (CC - 0.68,  $p < 0.0001$ ), West (CC - 0.65,  $p < 0.0001$ ), and Northeast (CC - 0.48,  $p < 0.0001$ ).

## 4. Discussion

To understand the overall impact of the COVID-19 pandemic on interventional stroke care, we have studied the sales of devices utilized for thrombectomy and cerebral aneurysm treatment procedures from 2018 to 2020, thus extrapolating the changes in device sales to procedural volume changes. Based on sales data from 945 hospitals in the United States, we report a significant decline in device sales from 2019 to 2020 (January through June) relating to thrombectomy (- 3.7%) and cerebral aneurysm treatment (- 8.5%), which is in contrast to an increase in device sales from 2018 to 2019. The proportion of thrombectomy device sales by month in 2020 was strongly and negatively



**Fig. 1.** Cumulative incidence of diagnosed COVID-19 and thrombectomy device sales in the U.S. The red line shows the cumulative number of cases of COVID-19 per 100,000 inhabitants in 2020 from January through June. The blue line represents the rate of thrombectomy device sales in 2020. The dashed black line represents the rate of thrombectomy device sales in 2019, and the dashed gray line represents the rate of thrombectomy device sales in 2018. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)



**Fig. 2.** Cumulative incidence of diagnosed COVID-19 and aneurysm device sales in the U.S. The red line shows the cumulative number of cases of COVID-19 per 100,000 inhabitants in 2020 from January through June. The blue line represents the rate of aneurysm device sales in 2020. The green line represents the rate of flow diversion device sales only in 2020. The dashed black line represents the rate of aneurysm device sales in 2019, and the dashed gray line represents the rate of aneurysm device sales in 2018. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

associated with the cumulative incidence of COVID-19 in the U.S. overall. Even in April 2020, there was a 5% decline in thrombectomy device sales relative to March, and the South was the most impacted region with a decline of 6.8%. While stroke centers in Michigan and northwest Ohio reported a 75.6% reduction in the rate of mechanical thrombectomy procedures for March 2020 compared to February 2020 [4], and national imaging during stroke care was reported to have decreased by 39% [3], we are reporting a much lower decline in thrombectomy equipment sales throughout the U.S. Thus, while the collateral effect on emergent thrombectomy stroke care appears to be real, the degree of impact may be less than previously reported in smaller regional series. Thrombectomy is a unique procedure as the devices utilized, specifically stent retrievers and suction thrombectomy catheters, are highly specific to this emergent procedure. Therefore, studying thrombectomy device sales provides a unique methodology for evaluating the COVID-19 impact on emergent delivery of interventional stroke care. With a decline in the rate of COVID-19 cases, we saw a rise of thrombectomy device sales, and thus, cases, in the month of June.

Other studies have reported trends of decreasing stroke admissions during the COVID-19 pandemic, but reports have primarily focused on regional patterns. For example, a study conducted at a tertiary care hospital in West Michigan demonstrated a reduction of cases of acute ischemic stroke during the stay-at-home order from March 24 to April 23, 2020, but this finding was not statistically significant [5]. A similar study found a reduction in stroke admissions of up to 39.5% in May 2020 compared to the pre-COVID-19 era, defined as December 1, 2019–March 11, 2020 [6]. Outside of the U.S., regional studies have demonstrated similar findings. For example, at a primary care university hospital in Germany, ischemic stroke and transient ischemic attack cases significantly decreased when comparing January 2019–February 2020 with March and April 2020. However, the percentages and numbers of intravenous thrombolysis and mechanical thrombectomy procedures did not change during the pandemic, suggesting that adequate healthcare resources allowed for a maintenance of recanalization procedures [7]. Similar trends reflecting a maintenance of recanalization procedures during the public lockdown from March 21 to April 19 were seen at another hospital in Germany [8]. Another regional study in London, United Kingdom, demonstrated a significant reduction in stroke and transient ischemic attack admissions when comparing April and May 2020 to the same months in 2019. In this case, the number of thrombolysis and thrombectomy procedures decreased between the compared periods [9]. One meta-analysis including studies from several countries

demonstrated a reduction in stroke alerts, reperfusion, and mechanical thrombectomies, corroborating results from another global survey [10], during the pandemic; however, the pandemic periods were defined differently in each of the studies. By utilizing device sales as a marker of procedural case volume, our study is the first to report both national and regional trends in interventional stroke care during the COVID-19 pandemic in the U.S.

When evaluating the aneurysm coiling sales data, one must account for these devices being utilized for elective as well as emergent procedures. Thus, the impact of the pandemic on the volume of aneurysm treatment procedures will be greater given a combination of the collateral effect as well as the decline related to the cessation of elective surgical procedures post COVID-19 pandemic. This is in alignment with the drop of aneurysm equipment sales by 8.5% when comparing 2020–2019. Device sales for aneurysm treatment were negatively correlated with the incidence of COVID-19, thereby underscoring an association of the pandemic to a decline in aneurysm interventions. The collateral effect of the COVID-19 pandemic on cerebrovascular interventions appears to be a real effect with a decline in sales of associated equipment during April followed by increases in June 2020.

## 5. Conclusions

We report a negative correlation between the rising incidence of COVID-19 infections and the sales of stroke procedural equipment during the study period of January to June 2020 within the United States. This negative collateral effect appeared to be stabilizing with the rise in equipment sales in the month of June. Responses to the COVID-19 pandemic, as well as future pandemics, must consider the real negative collateral effect upon the stroke patient populations within the United States.

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## Presentations

A.R. Adapa, F. Siddiqui, A.S. Pandey. “Trends in cerebrovascular thrombectomy, cerebral aneurysm, and percutaneous coronary intervention device sales during the COVID-19 pandemic.” E-Poster. American Association of Neurological Surgeons Meeting, Orlando, FL, USA, August 2021.

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## CRedit authorship contribution statement

**Arjun Adapa:** Conceptualization, Methodology, Software, Formal analysis, Writing – original draft, Writing – review & editing. **Mouhammad Jumaa:** Conceptualization, Writing – review & editing. **Fazeel Siddiqui:** Conceptualization, Writing – review & editing, Supervision. **Giana Dawod:** Writing – review & editing. **Osama Zaidat:** Writing – review & editing. **Hitinder Gurm:** Writing – review & editing. **Aditya S. Pandey:** Conceptualization, Methodology, Formal analysis, Writing – original draft, Writing – review & editing, Supervision.

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