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# Trends in United States pediatric neurosurgical practice during the COVID-19 pandemic

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ABSTRACT

There is minimal information on COVID-19 pandemic's national impact on pediatric neurosurgical operative volumes. In this study, using a national database, TriNetX, we compared the overall and seasonal trends of pediatric neurosurgical procedure volumes in the United States during the pandemic to pre-pandemic periods. In the United States, the incidence of COVID-19 began to rise in September 2020 and reached its maximum peak between December 2020 and January 2021. During this time, there was an inverse relationship between pediatric neurosurgical operative volumes and the incidence of COVID-19 cases. From March 2020 to May 2021, there was a significant decrease in the number of pediatric shunt (−11.7% mean change, $p = 0.006$), epilepsy (−16.6%, $p < 0.001$), and neurosurgical trauma (−13.8%, $p < 0.001$) surgeries compared to pre-pandemic years. The seasonal analysis also yielded a broad decrease in most subcategories in spring 2020 with significant decreases in pediatric spine, epilepsy, and trauma cases. To the best of our knowledge, this is the first study to report a national decline in pediatric shunt, epilepsy, and neurosurgical trauma operative volumes during the pandemic. This could be due to fear-related changes in health-seeking behavior as well as underdiagnosis during the COVID-19 pandemic.



## 1. Introduction

On March 18, 2020, the Centers of Medicare and Medicaid Services recommended delaying elective surgeries in the United States due to the SARS-CoV-2 (COVID-19) pandemic [1]. Unlike other neurosurgical subspecialties, most pediatric neurosurgical cases are emergent or urgent since delayed operations can impede cognitive development. At the time of this report, there is minimal information on COVID-19's national impact on pediatric neurosurgical operative volumes. In this study, using a national registry, TriNetX, we compared the seasonal and overall trends of pediatric neurosurgical procedure volumes in the United States during the pandemic to pre-pandemic periods.

## 2. Methods

TriNetX (Cambridge, MA) is a national database consisting of electric medical records from 54 healthcare organizations (HCO) and 72 million patients throughout the United States. TriNetX was used to measure the average number of pediatric neurosurgeries performed during each of the seasons of the pandemic from March 2020 to May 2021. Using Current Procedural Terminology (CPT) and International Classification of Diseases (ICD-10) codes (Supplementary data-appendix 1), Trinetx was queried for common pediatric spine, craniotomy, shunt, epilepsy, and trauma surgeries on July 27, 2021.

The monthly mean operative volume per reporting HCO for each subcategory was compared with a pooled corresponding

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three-month average between March 2018 and February 2019 to represent the pre-pandemic period. Descriptive analyses were performed, and comparisons were made using a Student's *t*-test.

## 3. Results

In the United States, the incidence of COVID-19 began to rise in September 2020 and reached its maximum peak between December 2020 and January 2021. During this time, there was an inverse relationship between pediatric neurosurgical operative volumes and the incidence of COVID-19 cases (Fig. 1). From March 2020 to May 2021, there was a significant decrease in the number of shunt (−11.7% mean change, $p = 0.006$), epilepsy (−16.6%, $p < 0.001$), and neurosurgical trauma (−13.8%, $p < 0.001$) surgeries compared to pre-pandemic years (Table 1).

The seasonal analysis yielded a broad decrease in most subcategories in spring 2020 with significant decreases in spine, epilepsy, and trauma cases. Spine, cranial, and trauma procedures returned to its pre-pandemic volumes during the summer, while shunt and epilepsy procedures met pre-pandemic levels during the fall of 2020. As COVID-19 cases began to increase in winter 2020, all 5 subcategories had fewer surgeries but only epilepsy and trauma surgeries showed significant decreases. Similar to summer 2020, the number of surgeries in most subcategories increased in Spring 2021. Spine and epilepsy procedures showed significant increases compared to pre-pandemic periods. However, there was a significant decrease in shunt surgeries in spring 2021 compared to pre-pandemic months (Table 1).

## 4. Discussion

To the best of our knowledge, this is the first study to report a national decline in pediatric shunt and epilepsy operative volumes during the pandemic. This could be due to fear-related changes in health-seeking behavior as well as underdiagnosis. Previously, Leung et al reported a significant decrease in adult seizure admissions to hospitals throughout Hong Kong due to changes in health care utilization which could have prevented pediatric patients from seeing their doctors as well [2]. Furthermore, declines in in-person clinic visits might have limited screening capabilities leading to underdiagnosis of hydrocephalus and epilepsy [3]. Online education could also contribute to decreased surgical volumes because absence seizures and changes in behavior indicative of shunt failure may be primarily noticed in academic settings. Since many classes were online and pediatric patients might have had their cameras turned off, some neurological presentations might have been missed resulting in decreased operative volumes.

While other studies have reported decreased trauma surgeries during COVID-19, this is the first report of decreased pediatric neurosurgical trauma volumes throughout the pandemic [4]. Trauma surgeries were significantly decreased in spring 2020 and winter 2020 which coincided with peak COVID-19 cases. These findings could be due to travel restrictions and stay-at-home orders reducing opportunities for traumatic injuries such as motor vehicle accidents and sports injuries [4].

The seasonal variations in operative volumes were inversely related to the incidence of COVID-19. As mentioned earlier, there was a decrease in operative volumes in spring 2020 and winter 2020 followed by a rebound increase in operative volumes in summer 2020 and spring 2021. While this pattern could also be explained by decreased health-care utilization, some elective surgeries were likely postponed due to limited hospital resources. As COVID-19 cases began to decrease, individual institutions reported increased neurosurgical referrals and operations due to the long waiting lists for elective surgeries [5].

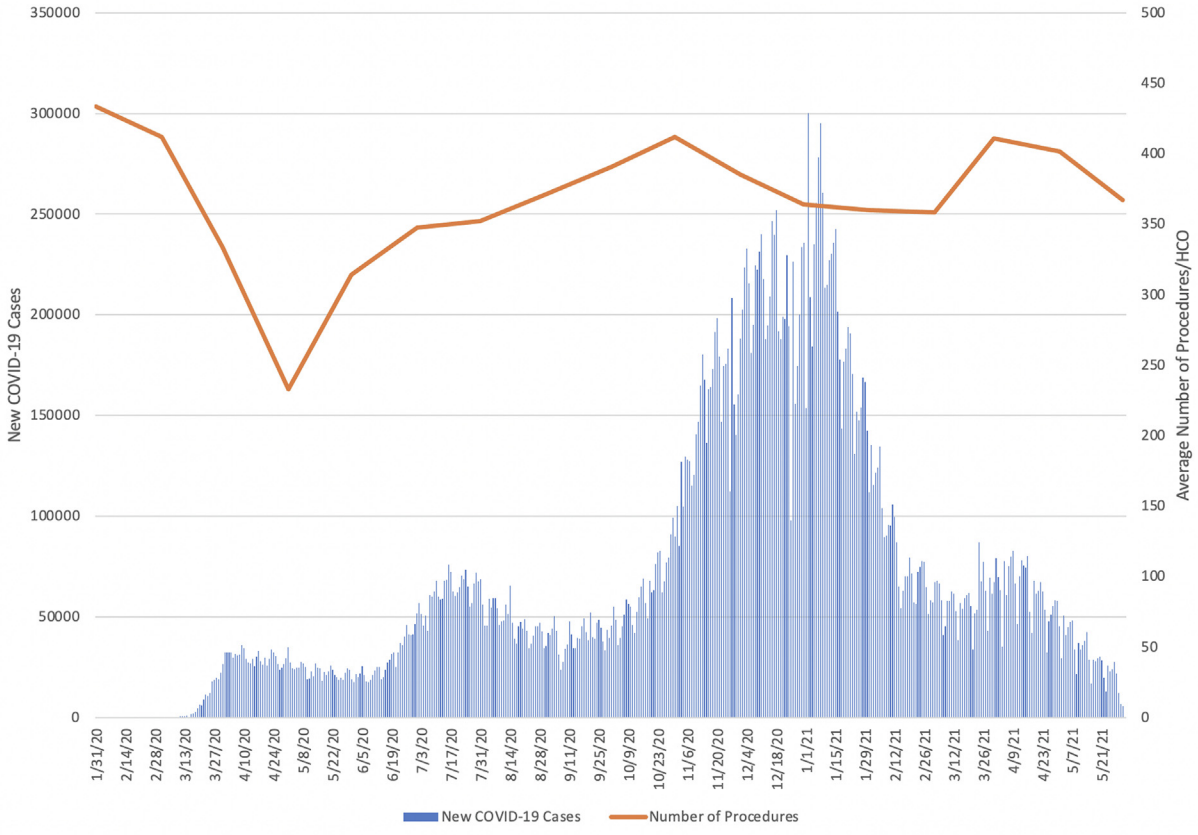


**Fig. 1.** United States pediatric neurosurgery procedures trends during the COVID-19 pandemic.

**Table 1**
Pandemic versus pre-pandemic trends of pediatric neurosurgery cases.

| | **Pandemic (March 2020 – February 2021) vs Pre-Pandemic** | | | |
|---|---|---|---|---|
| **Procedure** | **Pandemic Mean (SD)** | **Pre-pandemic Mean (SD)** | **Percent Change (%)** | ***p*-value** |
| ***Spine*** | 29.7 (5.9) | 30.9 (2.5) | −3.8 | 0.404 |
| ***Cranial*** | 3.3 (0.7) | 3.3 (0.7) | −0.4 | 0.957 |
| ***Shunt*** | 3.7 (0.6) | 4.2 (0.4) | −11.7 | 0.006† |
| ***Epilepsy*** | 8.2 (1.3) | 9.8 (0.8) | −16.6 | < 0.001† |
| ***Trauma*** | 306.9 (38.9) | 355.9 (27.3) | −13.8 | < 0.001† |
| | **March to May – 2020 vs 2018/2019** | | | |
| **Procedure** | **Pandemic Mean (SD)** | **Pre-pandemic Mean (SD)** | **Percent Change (%)** | ***p*-value** |
| ***Spine*** | 21.6 (6.7) | 29.5 (3.3) | −26.8 | 0.044† |
| ***Cranial*** | 3.6 (1.2) | 3.4 (0.5) | 6.2 | 0.719 |
| ***Shunt*** | 3.7 (0.7) | 4.3 (0.6) | −12.7 | 0.262 |
| ***Epilepsy*** | 6.7 (1.5) | 9.7 (0.9) | −30.8 | 0.006† |
| ***Trauma*** | 257.9 (44.1) | 347.3 (22) | −25.7 | 0.004† |
| | **June to August – 2020 vs 2018/2019** | | | |
| **Procedure** | **Pandemic Mean (SD)** | **Pre-pandemic Mean (SD)** | **Percent Change (%)** | ***p*-value** |
| ***Spine*** | 31.9 (1.5) | 30.8 (2.9) | 3.6 | 0.556 |
| ***Cranial*** | 3.6 (0.6) | 3.5 (0.8) | 0.3 | 0.985 |
| ***Shunt*** | 3.4 (0.6) | 4.2 (0.3) | −18.4 | 0.042† |
| ***Epilepsy*** | 8.8 (0.5) | 10.5 (0.8) | −15.8 | 0.012† |
| ***Trauma*** | 309.4 (12.3) | 335.4 (20.4) | −7.8 | 0.086 |
| | **September to November – 2020 vs 2018/2019** | | | |
| **Procedure** | **Pandemic Mean (SD)** | **Pre-pandemic Mean (SD)** | **Percent Change (%)** | ***p*-value** |
| ***Spine*** | 34 (1.3) | 31.6 (1.9) | 7.6 | 0.098 |
| ***Cranial*** | 3.2 (0.3) | 3.2 (0.7) | 0.3 | 0.981 |
| ***Shunt*** | 3.9 (0.4) | 4.3 (0.4) | −8 | 0.251 |
| ***Epilepsy*** | 9 (1.2) | 10.1 (0.8) | −10.8 | 0.136 |
| ***Trauma*** | 345.9 (15.2) | 382.1 (29.1) | −9.5 | 0.088 |
| | **December to February – 2020/2021 vs 2018/2019** | | | |
| **Procedure** | **Pandemic Mean (SD)** | **Pre-pandemic Mean (SD)** | **Percent Change (%)** | ***p*-value** |
| ***Spine*** | 31.3 (2.2) | 31.6 (1.6) | −0.9 | 0.82 |
| ***Cranial*** | 2.8 (0.5) | 3.1 (0.8) | −9.2 | 0.609 |
| ***Shunt*** | 3.9 (0.9) | 4.2 (0.3) | −7.8 | 0.43 |
| ***Epilepsy*** | 8.4 (0.5) | 9.2 (0.4) | −8.7 | 0.034† |
| ***Trauma*** | 314.5 (3.3) | 358.9 (15.7) | −12.4 | 0.002† |
| | **March to May- 2021 vs 2018/2019** | | | |
| **Procedure** | **Pandemic Mean (SD)** | **Pre-pandemic Mean (SD)** | **Percent Change (%)** | **P-value** |
| ***Spine*** | 36.5 (4.4) | 29.5 (3.3) | 23.8 | 0.03† |
| ***Cranial*** | 3.2 (0.8) | 3.4 (0.5) | −4.4 | 0.741 |
| ***Shunt*** | 3.3 (0.3) | 4.3 (0.6) | –22.3 | 0.035† |
| ***Epilepsy*** | 11.2 (0.9) | 9.7 (0.9) | 16 | 0.042† |
| ***Trauma*** | 339 (19) | 347.3 (22) | −2.4 | 0.598 |

This trend has important implications as the Delta variant is rapidly spreading throughout the United States. Previous peaks in COVID-19 cases were associated with a decrease in operative volumes likely due to fear of contracting the virus, decreased travel, and underdiagnosis. However, clinicians and academic institutions have now updated their policies permitting in-person interactions. This, along with the availability of vaccines, could decrease the rate of underdiagnosis thereby precipitating even longer waiting lists for elective surgeries after COVID-19 cases begin to decline again. We encourage pediatric neurosurgeons to prepare for these potential situations as new COVID-19 variants emerge.

This study is limited by TriNetX's aggregate nature of the data. Therefore, we are unable to stratify our results by geographic location and cannot assess how geographical variations in COVID-19 impacted pediatric neurosurgery cases. Furthermore, inconsistencies and inaccuracy of coding for diagnoses and procedures by hospitals may exist.

## 5. Availability of data and material

All relevant data are included in the manuscript draft, tables, and figures. Data for this study are not publicly available because of a data-use agreement. For requests to access the study data, please contact the corresponding author.

## 6. Consent to participate

Not applicable. Anonymized data was obtained from electronic health records.

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## Author contribution

PD, HP, OHT, SFK, MHS, and CAB conceived and designed the study; PD, HP, OHT, SFK, SG, RR, IL, and JV extracted and analyzed the data; PD, HP, OHT, SFK, and CAB wrote the manuscript; SFK, AJD, KLC, HSS, JAB, CDC, MHS, and CAB critically revised the manuscript for important intellectual content; CAB provided the overall supervision for the study. All authors commented and approved the manuscript.

## Ethical approval

Not applicable. We used the TriNetX Analytics Network, a global federated network that captures anonymized data from electronic health records in 54 health-care organizations in the USA, totaling 69·8 million patients. To comply with legal frameworks and ethical guidelines guarding against data re-identification, the identity of participating health-care organizations and their individual contribution to each dataset are not disclosed.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jocn.2022.01.001.

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