JNS PEDIATRICS

CLINICAL ARTICLE

# Advanced practice providers in pediatric neurosurgery: a single-institution analysis of clinical and surgical productivity

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**OBJECTIVE** Advanced practice providers (APPs) have experienced remarkable growth in surgical fields, collaborating closely with surgeons to optimize patient care. Although several specialties have evaluated the roles and safety of APPs in team-based care models, few studies have explored their impact on clinical and surgical productivity, especially in pediatric settings. This study aimed to evaluate the influence of enhanced APP utilization within the division of neurosurgery at a leading academic pediatric institution in the United States.

**METHODS** Productivity metrics were obtained from the Surgery Department Executive Committee annual reports from October 2011 to September 2023. Descriptive analyses were conducted to identify divisional trends in provider numbers, surgical and clinic volumes, total operating room (OR) hours, gross charges, and work relative value units.

**RESULTS** Since 2012, the division of neurosurgery has witnessed consistent growth in clinic encounters per APP and in overall clinic volume, peaking in 2023. The MD surgical conversion rate was lowest in 2016 (1 OR case for every 6.39 encounters) and peaked in 2019 (1 OR case for every 3.57 encounters). Financial metrics, adjusted for inflation, demonstrated notable increases in work relative value units and gross charges over the decade.

**CONCLUSIONS** Increased utilization and autonomy of APPs within the division of neurosurgery have facilitated greater procedural productivity and access to patient care. This study emphasizes the importance of integrating well-trained APPs into patient care models, allowing them to leverage their full expertise and training, particularly in pediatric surgical settings.

https://thejns.org/doi/abs/10.3171/2024.10.PEDS24345

**KEYWORDS** advanced practice providers; neurosurgery; pediatric; productivity

Advanced practice providers (APPs)—the collective term for physician assistants and nurse practitioners—were initially introduced into the clinical setting to improve and expand access to healthcare amid a primary care physician shortage. Since then, their ranks have experienced dramatic growth in both nonsurgical and surgical arenas, the latter of which has a strong need for APPs given their ability to work independently and directly alongside surgeons.[1] APPs contribute to the efficiency of practice in both clinic and operating room (OR) settings, enhancing patient access and continuity of care.[1] At our institution, APPs play an integral role in the global management of neurosurgery patients, from preoperative evaluation to postoperative follow-up. They independently evaluate patients, manage floor and ICU patients, and perform procedures at the bedside. Although there are notable benefits to using APPs in team-based care models, there has historically been some resistance, because APPs assumed greater autonomy.[2,3] Consequently, some providers may not regularly engage in autonomous patient care and are instead assigned nonclinical tasks.[4] Factors such as institutional barriers, variable reimbursement structures, malpractice concerns, and restrictive scope of practice regulations contribute to the underutilization of APPs.[5]

Several studies have evaluated the general roles, safety, and satisfaction of using APPs in neurosurgical practic-

**ABBREVIATIONS** APP = advanced practice provider; cFTE = clinical full-time equivalent; OR = operating room; SDEC = Surgery Department Executive Committee; wRVU = work relative value unit.

**ACCOMPANYING EDITORIAL** DOI: 10.3171/2024.11.PEDS24515.
**SUBMITTED** June 24, 2024. **ACCEPTED** October 2, 2024.
**INCLUDE WHEN CITING** Published online March 14, 2025; DOI: 10.3171/2024.10.PEDS24345.

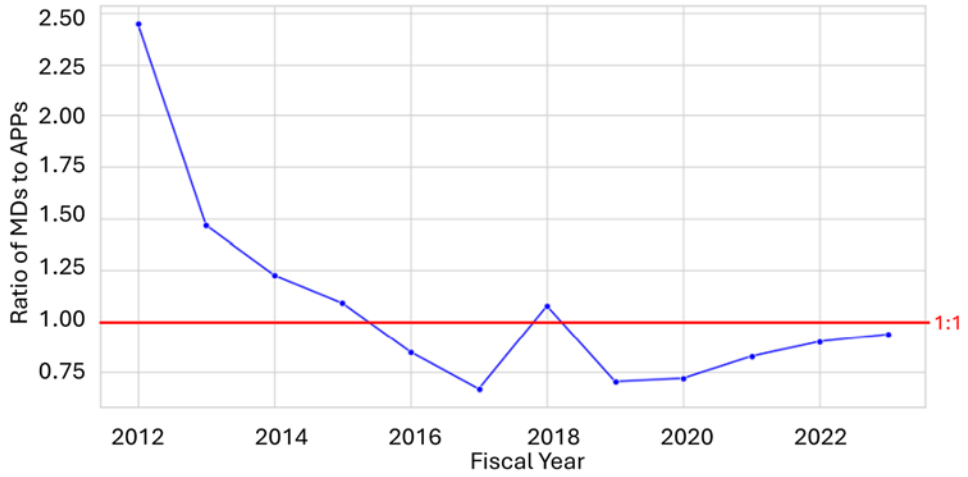


**FIG. 1.** MD to APP ratio per fiscal year. Figure is available in color online only.

es, but research on the impact of APPs in neurosurgery at large academic institutions remains limited, especially in pediatrics.[6–9] This study aims to assess the impact of increased APP utilization on surgical productivity within the division of neurosurgery at a single academic pediatric institution.

## Methods

A retrospective analysis of APP and surgeon performance metrics was conducted within the division of neurosurgery at a single large academic pediatric institution between October 2012 and September 2023. Our institution is one of the largest in the United States, with nearly 975 licensed beds and 45 ORs across 3 campuses in a single metropolitan area. Serving as a referral center for complex pediatric cases nationally and globally, our Department of Surgery manages a notably high caseload. Data were collected by fiscal year and analyzed in aggregate. All metrics were obtained from Surgery Department Executive Committee (SDEC) annual reports, an institutional tool used to evaluate productivity at the individual and divisional level. Metrics included the number of providers, surgical case volume, clinic volume, total OR hours, gross charges, and work relative value units (wRVUs). OR cases were tallied based on which service booked the operation. Each year of record extends from October 1 to September 30. Neurosurgical operations performed in conjunction with other surgical services, in which the other service booked the OR time, were not included in the tally of neurosurgery OR cases.

The neurosurgery division also maintains a separate database, and in this distinct database OR cases are tallied annually from July 1 to June 30. Surgical conversion rates were determined by the number of MD clinic encounters per OR case, and total clinic volume per OR case. This was inclusive of all new, return, and postoperative care. Gross charges were multiplied by the ratio of the Consumer Price Index in 2012 to the Consumer Price Index of the corresponding fiscal year to adjust for inflation. Clinical full-time equivalents (cFTEs) represented the number of providers per fiscal year, allowing us to account for variations in time allocated to administrative, educational, and private practice duties. The cFTE consists of time spent on billable clinical activities, including direct patient care, documentation, chart review, quality improvement tasks, and teaching while providing patient care.

Descriptive analyses were performed to identify divisional trends in productivity metrics and financial data during the evolution of APP utilization at our institution.

## Results

In 2012, the division of neurosurgery had 6 surgeons on the faculty and 2 APPs, operating with a provider ratio of 1 APP per 2.5 MDs by cFTE (Fig. 1). Subsequent hiring of both MDs and APPs resulted in a ratio of approximately 1:1 by 2016. In 2023, the division had 7 operating neurosurgeons and 8 APPs on staff. The provider ratio has consistently remained below 1:1 since 2019, with more APPs than MDs by cFTE. Clinic encounters, surgical volume, provider cFTEs, and APP/MD provider ratios are summarized in Table 1 by fiscal year. The largest clinic volumes were observed in 2023 for APPs and in 2013 for MDs, with 4157 and 5548 encounters, respectively. The largest surgical volume was observed in 2023—the most recent year analyzed—reaching 1192 cases in the SDEC database and 1269 OR cases in the neurosurgery database (Fig. 2). The COVID-19 pandemic resulted in a period of instability, with clinical delays and surgical backlog. As normal operations resumed, total OR cases surpassed pre-COVID volumes.

Total OR hours increased from 2882 hours in 2016 to 5129 hours in 2023, with an average increase of 9.32% per fiscal year. The largest period of growth occurred between 2017 and 2018, increasing by 27.33%.

Since 2012, there has been a consistent increase in the number of clinic encounters per APP, with a corresponding decrease in the number of clinic encounters per MD (Fig. 3). By 2022, APPs nearly matched MD clinic volume, completing 4055 encounters compared to the MDs' 4091.

The MD surgical conversion rate reached its lowest point in 2016 at 0.16 (1 OR case for every 6.39 clinic en-

**TABLE 1. Productivity metrics by fiscal year**

| Fiscal Yr | APP cFTEs | MD cFTEs | APP/MD Provider Ratio | APP Clinic Encounters | MD Clinic Encounters | Total OR Cases |
|---|---|---|---|---|---|---|
| 2012 | 2 | 4.9 | 1:2.5 | 442 | 5007 | 924 |
| 2013 | 3 | 4.4 | 1:1.5 | 696 | 5548 | 883 |
| 2014 | 4 | 4.9 | 1:1.2 | 1591 | 4912 | 867 |
| 2015 | 4.5 | 4.9 | 1:1.1 | 1888 | 4545 | 850 |
| 2016 | 6 | 5.1 | 1:0.85 | 3056 | 5458 | 854 |
| 2017 | 5.5 | 3.68 | 1:0.67 | 3868 | 3850 | 907 |
| 2018 | 4.5 | 4.84 | 1:1.1 | 2932 | 4614 | 1063 |
| 2019 | 6 | 4.23 | 1:0.71 | 3683 | 3976 | 1112 |
| 2020 | 7 | 5.05 | 1:0.72 | 3288 | 3766 | 947 |
| 2021 | 6.2 | 5.14 | 1:0.83 | 3367 | 4693 | 1022 |
| 2022 | 6.8 | 6.13 | 1:0.90 | 4055 | 4091 | 972 |
| 2023 | 6.8 | 6.37 | 1:0.94 | 4157 | 5159 | 1192 |

counters) and peaked in 2019 at 0.28 (1 OR case for every 3.57 clinic encounters) (Fig. 4). Although it initially decreased at the onset of COVID-19, a general upward trend has since resumed, reaching 0.23 in 2023 (1 OR case for every 4.35 clinic encounters). The combined surgical conversion rate (MD + APP clinic encounters) has demonstrated an upward trend, most notably since 2016 when the conversion rate was 1 OR case for every 9.97 clinic encounters.

Since 2012, the division of neurosurgery has observed a 99% increase in total wRVUs, with an average increase of 7.1% per fiscal year (Fig. 5). After adjusting for inflation, gross charges increased by 36.76% across the division, with an average yearly increase of 3.65% (Fig. 6).

## Discussion

Enhanced autonomy and increased utilization of APPs have facilitated greater productivity and access to care within the division of neurosurgery at our institution. The integration of APPs into team-based care models has been increasingly evaluated in recent years, including within surgical fields. Several studies have examined the impact of APPs in various subspecialties, reporting increased surgical volume and reduced wait times without compromising quality of care.[10–13] Although there is a significant body of literature on the general roles, safety, and satisfaction associated with APPs in neurosurgical practices, assessments involving productivity metrics are limited.[6–9] Evaluations of APPs within pediatric institutions are also scarce and primarily consist of national surveys assessing their roles and practice settings.[14–16] To address this gap, our study examines the increased utilization of APPs in neurosurgery at a large pediatric academic institution and provides an analysis of productivity trends spanning the last decade.

Our institution began employing APPs in 2012 when surgical departmental leadership recognized that the Department of Surgery's growth would soon surpass the available resident coverage. APPs were added to a stable

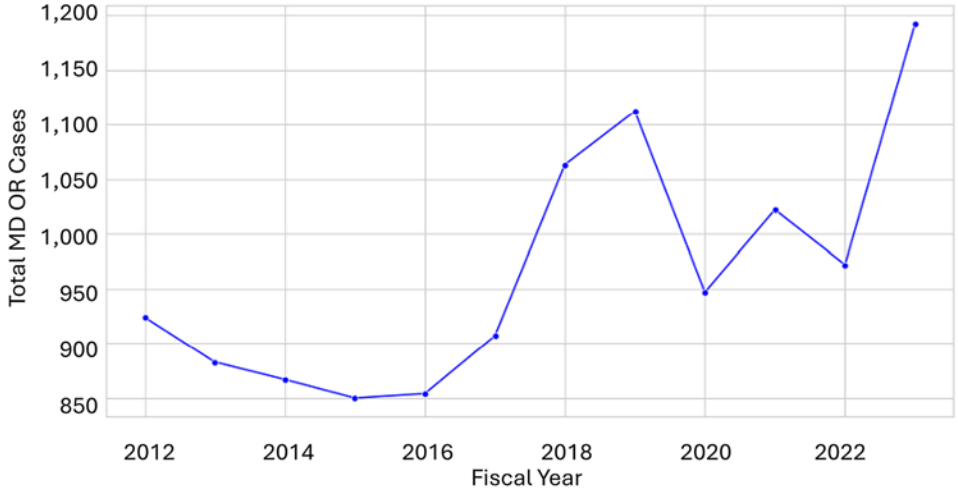


**FIG. 2.** Total surgical case volume. Figure is available in color online only.

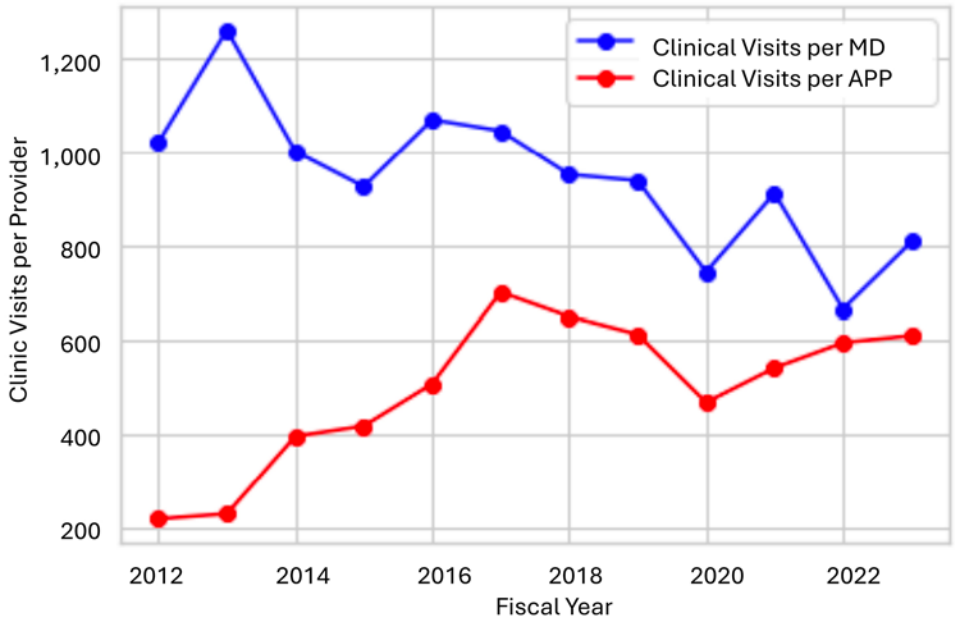


**FIG. 3.** Clinic visits per provider. Figure is available in color online only.

number of surgical trainees in each division to improve OR coverage, ensure continuity of care, and enhance patient and family access to services. In the division of neurosurgery, there has consistently been a structured team including 2 junior neurosurgery residents, 1 senior neurosurgery resident, and 1 pediatric neurosurgery fellow on service at all times. The division of neurosurgery initially employed nurse practitioners and gradually expanded to include physician assistants. Although these providers extended the capacity of the division, their scope of practice was not yet well defined.

As divisional growth continued, the role of APPs evolved to enhance their autonomy and improve efficiency. Neurosurgery APPs now work in a hybrid role, with inpatient and outpatient responsibilities. In the outpatient setting, APPs independently evaluate patients in traumatic brain injury, infant plagiocephaly, and older plagiocephaly clinics. They also independently evaluate patients in the tandem craniofacial and postoperative clinics, where they work alongside surgeons who are available for support and escalation of care when appropriate. APPs complete all types of encounters, including pre- and postoperative visits, new and returning visits, add-on appointments, and emergency center follow-ups. Certain diagnoses are preferentially managed by neurosurgeons, particularly those involving complex surgical planning or high-risk conditions. For example, patients with confirmed craniosynostosis, vascular malformations, refractory epilepsy,

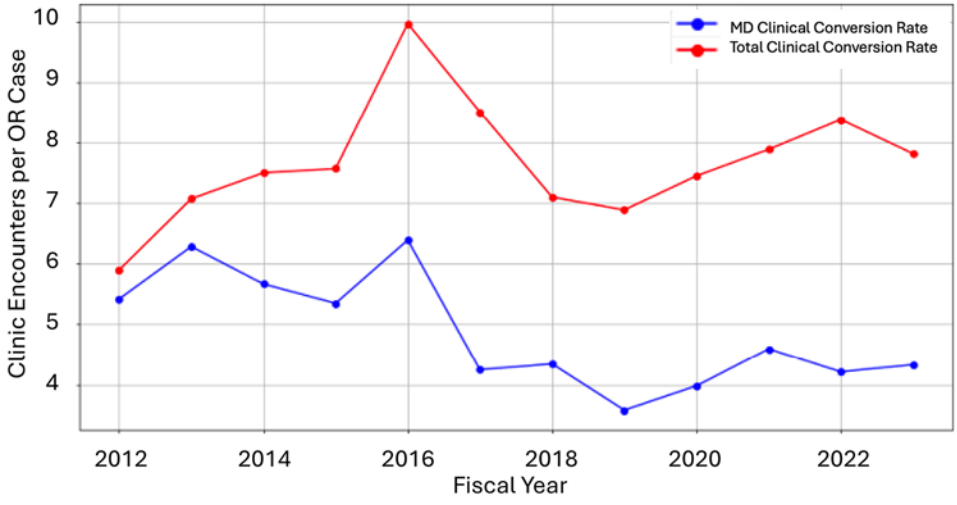


**FIG. 4.** Surgical conversion rates for MD-only clinic visits and total divisional clinic visits. Figure is available in color online only.

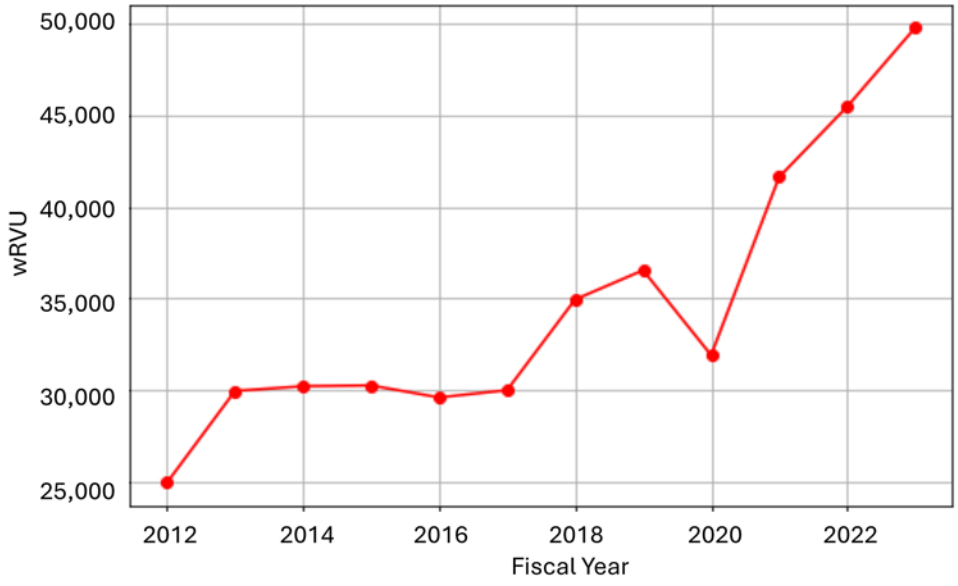


**FIG. 5.** Total divisional wRVUs. Figure is available in color online only.

myelomeningoceles, or hydrocephalus requiring shunt placement are nearly always seen in the neurosurgeons' clinics.

In the inpatient setting, APPs manage the floor and ICU patients, commonly seeing initial consults and discharging patients. APPs also play an important role in maintaining patient access to care, completing peer-to-peer insurance verifications for the division in between their inpatient duties when able. Despite the increase in APP autonomy, educational opportunities for residents and fellows have remained consistent. Residents are actively involved in both morning and afternoon rounds, consultation management, OR cases, and various weekly educational conferences. Clinic participation for residents and fellows is tailored to individual interests and service needs, with residents continuing to cover all primary consultations. This educational framework ensures that resident and fellow learning experiences are preserved even as the scope of APP practice evolves.

Neurosurgery APPs do not participate as first assistants in the OR at our institution. However, they frequently perform procedures independently at bedside, often with support from child life specialists. These procedures include removal of drains, such as external ventricular, Jackson-

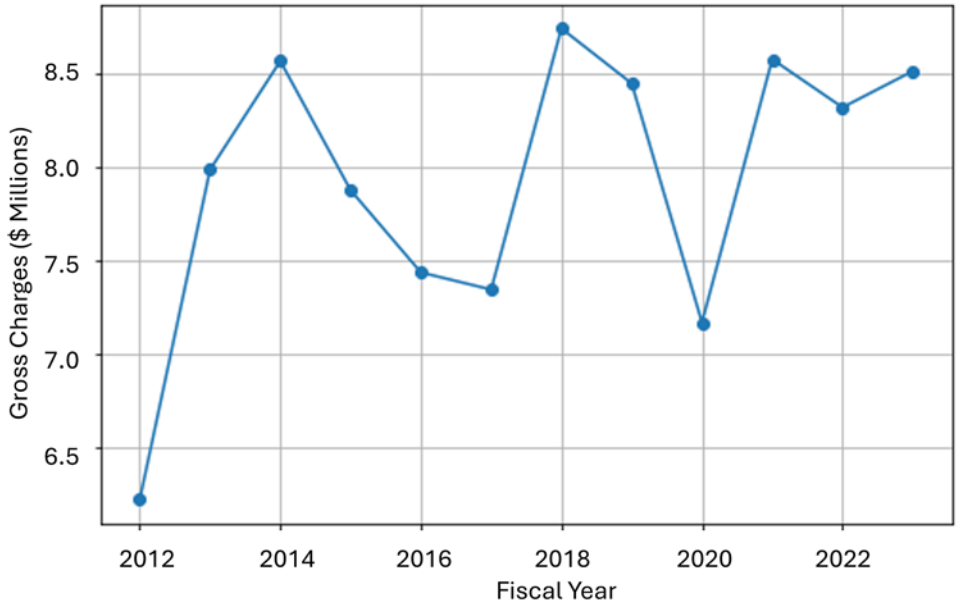


**FIG. 6.** Divisional gross charges after adjustment for inflation. Figure is available in color online only.

Pratt, lumbar, and Hemovac drains; as well as bolt removal, suture and staple removal, oversewing wounds, lumbar punctures, and shunt reprogramming; and various taps including shunt taps, Ommaya taps, and fontanelle taps.

In addition to their clinical responsibilities, APPs in our neurosurgery division have demonstrated increased research involvement. APPs conduct various procedures for ongoing multidisciplinary studies, primarily Ommaya taps and intrathecal antibiotic administration, and have presented research at both national and regional conferences.

As the division of neurosurgery expanded its team of APPs, a corresponding increase was observed in both clinical and surgical productivity. The total clinic volume, including both MD and APP encounters, increased by a factor of 1.7—from 5449 encounters in 2012 to 9316 in 2023. The total APP clinic volume increased 9-fold over the same period, and grew by a factor of 2.76 per provider; from 221 encounters per APP in 2012 to 611 encounters per APP in 2023. With such substantial clinic contributions, APPs may be generating additional operative time for MDs by conducting routine follow-up encounters and consultations. With 30-minute appointment slots, APPs completed 2079 hours of clinic encounters in 2023, thereby providing surgeons with additional time to evaluate patients who were likely to require surgery. This is further supported by the surgical conversion rate and the overall increase in case complexity. Over the past decade, MDs have completed fewer clinic encounters per OR case, despite an overall increase in clinic volume. Additionally, tumor and epilepsy cases have doubled, whereas shunt cases have remained relatively stable. The allocation of surgeon block time has also expanded, from 1.4 guaranteed rooms per day (with a second room available only twice per week) to 2 guaranteed rooms daily starting in 2023. Furthermore, there are an additional 1–2 rooms available for elective, multiservice, fetal, and add-on cases.

Overall productivity trends suggest that the division of neurosurgery achieves greater productivity and improved patient access when APPs function as autonomous providers. This may have positive downstream effects, including cost reduction and additional revenue generation. Our financial analysis revealed overall divisional growth in total wRVUs and gross charges after adjustment for inflation. Although this trend appropriately corresponds with divisional increases in both surgical and clinical productivity, it is particularly notable that total divisional wRVUs have consistently increased since 2016 despite a relatively stable number of MDs (approximately 5–6 cFTE) and APPs (approximately 6–7 cFTE). Divisional gross charges decreased substantially twice, once between 2014 and 2017, and again in fiscal year 2020 during the COVID-19 pandemic. The initial decrease occurred during a significant time of transition within the division, including multiple APP hires and ongoing refinement of their roles. This decrease in total gross charges may be attributed to the onboarding process and APP training; however, additional analysis is necessary to fully interpret this trend. Although our findings offer insight into divisional financial trends across the past decade, the SDEC reports lack sufficient granularity to attribute financial gains or losses to any single factor.

To the best of our knowledge, no studies have examined the cost-effectiveness of APPs in neurosurgery at an institutional or provider level. Several small practices in other surgical specialties have completed comprehensive financial analyses, revealing increased cost savings and net profits after integrating APPs into their practices.[10,11] Savings were primarily attributed to directing time-intensive processes away from surgeons to lower-cost providers. Chao et al. noted that the profits associated with incorporating APPs into their practice offset the costs of their employment. However, they also mention that even if APPs do not fully offset their salary and training costs, their contributions to clinical and surgical productivity yield clear economic benefits, such as improved access to care and facilitation of additional revenue without the significant time and financial investments associated with hiring additional surgeons.[10] An orthopedic surgery department revealed similar findings after introducing APPs as autonomous providers, observing increases in total clinic volume, wRVUs, total payments, and greater operating projections despite decreases in MD clinic volume.[17]

In addition to ongoing concerns regarding the economic value of APPs, there are several perceived challenges surrounding their use as autonomous providers, especially in surgical subspecialties. Perhaps the largest concern is the potential for negative patient outcomes associated with less experienced providers. Consequently, patient outcomes of APP-led encounters have been studied extensively across both surgical and nonsurgical specialties. Complications, mortality rates, readmission rates, number of visits, and quality of life scores have all been evaluated, with most studies finding equal or greater care provided by APPs compared to physicians. Only 2 reports demonstrated mixed or equivocal outcomes.[18,19]

Other common concerns include the potential for misdiagnosis, poor triage, or overutilization of diagnostic tools due to perceived knowledge gaps or differences in training. Two studies have addressed this concern within neurosurgery by evaluating APP plagiocephaly screening at high-volume clinics without surgeon input.[6,7] There were no missed diagnoses of synostosis in either study, nor did any of the patients managed by APPs ultimately require surgical intervention. In addition to assessing the sensitivity of initial evaluations by APPs, Kuang et al. examined the frequency of CT orders placed.[7] Of the 1228 patients independently evaluated by pediatric nurse practitioners, 590 (48%) were referred for surgeon evaluation due to suspicion of craniosynostosis. Of the referred patients, 101 had orders placed for CTs by the APP prior to surgeon evaluation, and a similar number of CTs was ordered by surgeons (94). Among the patients who had CT imaging ordered by APPs and surgeons, 34% and 54% were diagnosed with craniosynostosis, respectively. Overall, utilization of APPs for screening led to reduced radiation exposure and eliminated the need for evaluation by surgeons in more than half of patients.[7] Hoffman et al. did not comment on the frequency of CT imaging; however, the authors noted that only 12 of the 88 patients (14%) screened by APPs returned to the surgeon for an MD evaluation. Eight were requested by nurse practitioners to assess the progression of head shape, and only 2 were to

rule out synostosis.[6] Both studies also noted an increase in patient volume and overall efficiency.[6,7] Kuang et al. reported a greater than 4-fold increase in annual primary cranial vault reconstructions and attributed this increase in productivity to reduced burden on surgeon subspecialists and improved patient access.[7]

Similar to concerns regarding misdiagnosis and overutilization of diagnostic tools, there are questions about whether the use of APPs may lead to increased follow-up frequency. Although quantifying this impact directly is challenging due to variability in individual surgeon practices, anecdotal evidence suggests that APPs generally mirror the practices of their supervising physicians. At our institution, APPs do not inherently increase follow-up appointments but ensure that follow-up care and initial evaluations adhere to the division's established protocols and practices.

Although quality of care and patient safety are important to address, increasing the utilization and autonomy of APPs is not synonymous with substituting MD encounters and procedures with less-skilled providers. Expanding their scope of care offers an opportunity to train and tailor APPs to become proficient in meeting the unique needs of surgical practices. Within our division of neurosurgery, APPs complete a 6-month orientation pathway that includes weekly didactics, quizzes, procedure check offs, and shadowing across all settings. They can only transition to independent providers once their training has been reviewed and approved by neurosurgery attendings. Similarly to well-trained surgical residents, APPs develop confidence and self-awareness throughout their training. They learn to recognize their limits and can appropriately identify when it is necessary to escalate care to the level of physicians.

Although this study highlights several noteworthy productivity trends within our division of neurosurgery, it is important to address its inherent limitations. The SDEC annual reports lack discrete metrics such as encounter lengths, surgical case durations, wait times, and patient retention rates, which could offer greater insights into productivity dynamics. Although total OR hours were reported in the SDEC reports from 2016 onward, it is important to recognize the challenge of interpreting this productivity metric. The inability to control for varying surgical case durations requires cautious interpretation. Furthermore, all OR cases reported in the SDEC's findings were exclusively booked by neurosurgery. Operations performed in collaboration with other surgical services were not included, which was likely to have led to an underestimation of the total number of cases and total OR hours. Additionally, it is challenging to compare individual surgeon data over this period, because 6 of our 8 current neurosurgeons have been recruited since 2014, and their productivity has naturally increased as they have established their practices.

Financial data are also limited and do not include values such as salary, fringe benefits, overhead costs, and total encounter costs per provider. Without access to these data, it is challenging to assess the true impact of APP integration on divisional revenue. Additionally, APPs provide substantial value to a practice through indirect contributions that are difficult to quantify. Clinic encounters and billable procedures are well-defined sources of revenue; however, costs related to improved perioperative flow and greater patient access cannot be assigned discrete values. The cFTE value served as a surrogate for the number of providers, to reduce the influence of schedule and workload variability. Nevertheless, we could not account for time spent on tasks beyond clinical roles, such as administrative responsibilities, teaching, or research.

## Conclusions

The increased utilization and autonomy of APPs in the division of neurosurgery have facilitated greater productivity and access to care. As APPs continue to expand their scope of practice, surgical administration and subspecialty divisions should revise patient care models to enable them to practice to the fullest extent of their training. Moving forward, efforts will focus on exploring the impact of APP integration in other surgical divisions at our institution. To further investigate the economic impact, future studies should include comprehensive analyses of associated costs and revenue generated from both APPs and surgical providers.

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## Disclosures

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

## Author Contributions

Conception and design: Layon, Marsack, Parham, Burns, Hollier. Acquisition of data: Layon, Marsack, Burns, McClernon. Analysis and interpretation of data: Weiner, Layon, Parham, Burns, McClernon. Drafting the article: Weiner, Layon, Parham, Burns. Critically revising the article: Weiner, Layon, Marsack, Burns, McClernon, Hollier. Reviewed submitted version of manuscript: Weiner, Layon, Marsack, Burns, McClernon, Hollier. Approved the final version of the manuscript on behalf of all authors: Weiner. Statistical analysis: Parham. Administrative/technical/material support: Marsack.

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