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ORIGINAL RESEARCH

Anesthesiology Residency Case Volumes Through the COVID-19 Pandemic: National Trends in Training Experience and Gender Equity (2018–2023)

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INTRODUCTION

Measuring the number of cases a trainee performs has served as a foundational surrogate for clinical experience and surgical proficiency for decades.^{1,2} Within the United States, the Accreditation Council for Graduate Medical Education (ACGME) utilizes the resident case log system to objectively document operative volume, ensuring that residents meet or exceed required minimums in specific patient categories and procedure types to qualify for graduation. Beyond residency, these data are increasingly utilized by hospital systems as part of the credentialing process for clinical privileges.³

Despite their importance, case logs are often plagued by significant inter-resident variability and inaccuracies inherent to self-reporting.^{1,4} In anesthesiology, total case counts are often influenced by the number of specific rotations (such as pediatric or obstetric) and the amount of dedicated research time, which can reduce clinical exposure.¹ Furthermore, evidence from multiple surgical specialties suggests that residents may underreport cases once they reach minimum thresholds, or they may feel they have not participated enough in a case to justify logging it.^{4,5}

A growing body of national data highlights persistent differences in operative volume based on resident gender.⁶ Recent large-scale studies in general surgery, urology, and ophthalmology have consistently

demonstrated that female residents log significantly fewer cases than their male peers.^{6–8} In general surgery, this gap was found to be statistically significant across nearly all categories with a difference of 30 to 40 cases potentially equating to 1 to 3 months of lost surgical training.⁷ These findings suggest a potential structural bias in clinical training environments that may impact technical competence and future career choices; however, the literature may be more complex with some studies showing the gender gap closing significantly and reviews in plastic surgery reporting negligible sex-based disparities. Moreover, substantial geographic variation in case types suggests that cases and resident sex may be unevenly distributed, making geography a significant confounding variable.^{7–9}

The ACGME minimum case requirements for anesthesiology training were established through expert consensus to ensure adequate procedural exposure across key clinical domains. However, the evidence directly linking specific case volume thresholds to clinical competency or patient outcomes remains limited, and the relationship between case numbers and proficiency likely varies by procedure type and individual learner characteristics.

Given these limitations in the existing literature and the ongoing evolution of anesthesiology training, this study aims to provide a comprehensive national analysis of procedural case volumes

across 5 consecutive graduating cohorts (2018–2023), spanning the critical period before, during, and after the COVID-19 pandemic. Specifically, we sought to (1) characterize national trends in total and category-specific case volumes to assess training consistency and resilience, (2) evaluate gender-based differences in procedural exposure across all major anesthesia categories to determine whether disparities observed in other surgical specialties extend to anesthesiology, and (3) examine rates of minimum case requirement attainment to assess the adequacy of current ACGME standards in ensuring uniform training experiences. By analyzing resident-level data from all ACGME-accredited programs, this study provides the most contemporary and comprehensive assessment of anesthesiology training equity and quality in the modern era with implications for residency program design, accreditation standards, and the ongoing transition to competency-based medical education.

METHODS

Design and Participants

This study used a retrospective cohort design to examine procedural case volumes among anesthesiology residents. The data set comprised 5 consecutive graduating cohorts from 2018–2019 through 2022–2023, representing all ACGME-accredited anesthesiology

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residency programs in the United States. The study was approved by the Stanford University Institutional Review Board (IRB# 70214), which granted a waiver of informed consent because all data were fully deidentified and no direct contact with participants occurred.

Data Source

The data for this study were obtained from the ACGME case log system, which collects standardized procedural documentation for all residents enrolled in ACGME-accredited anesthesiology training programs in the United States. Residents are required to record individual procedures performed during their clinical training, and these entries are aggregated by the ACGME into defined procedural categories for the purpose of monitoring educational exposure and ensuring compliance with minimum training requirements. The data set provided for this study contained deidentified, resident-level annual case totals across key ACGME-defined categories, including peripheral nerve blocks, epidurals, spinal, obstetric anesthesia procedures, and pediatric anesthesia encounters. The detailed procedure categories and corresponding minimum case numbers and the mean number of cases per trainee for each procedural category across the 5 graduating cohorts are provided in Table 1.

Demographic information, including resident gender, was obtained from the Association of American Medical Colleges and linked to the ACGME case log data using unique resident identifiers under a secure data-use agreement.

Statistical Analysis

Given the large sample sizes in this national data set, we calculated effect sizes using Cohen d to distinguish between statistical significance and practical or educational significance. Whereas large sample sizes can yield statistically significant p -values even for trivial differences, effect sizes provide a standardized measure of the magnitude of gender differences independent of sample size. We followed the Cohen conventional benchmarks with values of 0.2, 0.5, and 0.8 representing small,

medium, and large effects, respectively.¹⁰ In the context of medical education and procedural training, even small effect sizes ($d = 0.2$) may be educationally meaningful when they reflect systematic disparities in clinical exposure that could accumulate over the course of residency and impact long-term practice patterns and confidence with specific procedures. Effect sizes also allow for comparison across different procedural categories with varying baseline case volumes and permit assessment of whether observed gender differences are consistent or variable across training domains. Data compilation and analyses were conducted using Stata 17 (College Station, TX).

RESULTS

A total of 8879 residents (67% male and 33% female) across 5 graduation years were included in the analysis (Table 2). The gender distribution was relatively stable over time with men comprising approximately two thirds of trainees in each cohort. Specifically, the proportion of male trainees ranged from 65% to 69%, whereas female trainees accounted for 31% to 35% across graduation years. Overall, the gender composition was consistent across cohorts with a modest increase in the proportion of male trainees in the most recent graduation years.

Overall Case Volumes

Across graduation years, the overall mean number of cases declined from 1090 (95% CI, 1081–1098) among 2018–2019 graduates to 1061 (95% CI, 1053–1070) among 2019–2020 graduates, followed by a gradual recovery in subsequent years, reaching 1077 (95% CI, 1069–1085) in 2022–2023 (Figure 1A). Generally, graduates completed higher case volumes in total peripheral nerve block, patients <12 years old, and total epidural procedures, whereas the fewest cases were observed among patients <3 months old. Several procedure categories demonstrated increasing trends over time, including total peripheral nerve blocks (Figure 1G) and life-threatening pathology cases (Figure 1K), particularly from 2020–2021 onward. In contrast, declining trends were observed in pediatric cases, including patients younger <12 years old (Figure 1D) and patients <3 years old (Figure 1C)

as well as total epidural (Figure 1H) and new patient pain evaluation cases (Figure 1L). Other categories, such as total spinal (Figure 1I), total vaginal delivery (Figure 1E), cardiac (Figure 1J), intracerebral (Figure 1N through O), and intrathoracic noncardiac procedures (Figure 1P), remained relatively stable with overlapping confidence intervals across years. Importantly, mean case volumes exceeded the ACGME-required minimums for all procedural categories.

Case Minimum Attainment

The proportion of graduates who did not meet minimum graduation requirements was consistently very low across cohorts. Specifically, 0.12% of graduates in 2018–2019, 0.37% in 2019–2020, 0.38% in 2020–2021, 0.13% in 2021–2022, and 0.09% in 2022–2023 did not meet minimum case requirements. Overall, across the 5 graduating cohorts, only 0.22% of trainees failed to meet minimum graduation requirements, indicating that nearly all graduates satisfied established training benchmarks.

The gender distribution of not meeting the minimum is 0.20% (male) and 0.25% (female), $P = .086$. Across the cohort, overall compliance with minimum requirements was excellent. The limited shortfalls observed were concentrated in pediatric categories, particularly among patients younger than 12 years and infants younger than 3 months as well as in intrathoracic noncardiac procedures, suggesting potential challenges with exposure or scheduling in these areas. Gender differences in noncompliance were modest (0.20% in males vs 0.25% in females; $P = .086$) and not statistically significant although patterns varied by category, likely reflecting differences in case mix, rotation assignments, or access to specific clinical experiences. Table 3 presents the distribution by category for percentage not meeting minimum requirements.

Gender

Across all the cases combined, male trainees consistently recorded significantly higher mean overall case volumes than female trainees across all 5 graduation cohorts (P values ranging from <.001 to .017; Figure

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2A). It is worth noting that the effect sizes for the significant findings, represented by Cohen *d*, ranged from 0.12 to 0.31, indicating small effects. Statistically significant gender differences were also observed in several case categories. Male trainees had significantly higher mean case volumes than female trainees in total peripheral nerve block cases, total epidural, total cardiac cases, and life-threatening pathology cases across 3 graduation cohorts. Significant gender differences were also seen in total vaginal delivery (Figure 2E) with male trainees recording higher case volumes in the 2020–2021 ($P = .006$, Cohen $d = 0.14$) and 2022–2023 cohorts ($P = .049$, Cohen $d = .10$). In the total vascular (major vessels) category (Figure 2M), male trainees again demonstrated significantly higher mean case volumes in 4 graduation cohorts, 2018–2019 ($P = .002$, Cohen $d = 0.16$), 2019–2020 ($P = .013$, Cohen $d = 0.13$), 2020–2021 ($P = .001$, Cohen $d = 0.17$), and 2021–2022 ($P = .019$, Cohen $d = 0.12$). In contrast, categories such as total spinal, total intrathoracic noncardiac cases, and pediatric-related categories (patients <12 years, <3 years) showed no statistically significant gender differences across graduation cohorts. These overall and category-specific gender differences are illustrated in Figure 2.

Our analysis compared mean case volumes by gender without adjustment for potential confounding variables such as program size, geographic location, research time allocation, or rotation distribution. These factors may influence case exposure and could partially explain observed differences. As such, the gender-based differences reported should be interpreted as descriptive associations rather than causal relationships.

DISCUSSION

This study analyzes the findings of national anesthesiology case logs across 5 graduation cohorts (2018–2023) within the broader landscape of graduate medical education. Our analysis of nearly 8900 residents demonstrated stable gender composition on a national scale, resilience in the face of pandemic-related disruptions, and an exceptionally high

rate of ACGME minimum attainment (99.78%) even as persistent gender-associated differences in case volumes remain a significant area for structural improvement.

Temporal Trends

The observed decline in case volumes for the 2019–2020 cohort aligns with data from other specialties that faced elective procedure shutdowns during the initial wave of the COVID-19 pandemic.¹¹ Whereas surgical procedures nationwide saw an approximately 48% decrease during the initial 2020 shutdowns, our data suggests that anesthesiology training experienced a gradual recovery, reaching prepandemic levels by the 2022–2023 academic year. This recovery mirrors findings in independent plastic surgery and urology residencies, in which total case volumes remained stable or rebounded quickly despite temporary halts.^{6,11}

Within anesthesiology, the post-2020 increase in peripheral nerve blocks and life-threatening pathology cases suggests an adaptive focus on regional anesthesia techniques and high-acuity care. This shift toward specific procedural expertise is reflected in other fields, such as the transition from open to thoracoscopic (video-assisted thoracoscopic surgery) techniques in thoracic surgery and the rise of minimally invasive approaches in urogynecology.^{12,13}

Although anesthesiology residency programs implemented numerous educational adaptations during the COVID-19 pandemic, including simulation-based training, virtual didactics, and telemedicine-enhanced learning, these interventions primarily supported educational continuity rather than procedural case accrual. The recovery in case log volumes observed in later cohorts is more likely attributable to the gradual resumption of elective surgical procedures, restoration of clinical services, and increased availability of operative experiences. These findings suggest that, whereas educational innovations helped maintain training during periods of disruption, the normalization of procedural exposure was driven principally by the return of clinical

case opportunities.¹⁴ These coordinated adaptations may have contributed to the relatively rapid normalization of anesthesiology procedural exposure observed nationally in our study.

Persistent Gender Differences in Procedural Volume

A central finding is that the mean overall number of cases logged by male trainees is significantly higher than the number of cases logged by female trainees across each of the cohorts but not in each procedural type. Whereas the effect size was small (Cohen d : 0.11–0.19), this disparity is a consistent theme across surgical subspecialties in the sources:

- Urology: Female residents log 3.4% fewer cases on average than their male peers over an 11-year period.⁶
- General Surgery: Male chief residents log roughly 37 more cases than females, a gap potentially equating to 1 to 3 months of lost training.⁷
- Ophthalmology: Women log 4.4% fewer cataract surgeries and 7.4% fewer total procedures.⁸

The consistency of these findings across specialties suggests that the gap may not be due to individual choices but potentially to systemic factors, such as differences in granted operative autonomy, mentorship access, or structural biases in case allocation.^{6,8} Reassuringly, the absence of significant gender differences in pediatric and spinal cases in our anesthesiology cohort suggests that these disparities are not universal across all clinical domains.

To address the observed shortfalls in case log while sustaining high compliance, programs should audit case log distribution by rotation and site to verify equitable access with particular attention to pediatric and intrathoracic noncardiac exposures. Where gaps are identified, targeted scheduling, structured mentorship, and simulation-based curricula can buffer variability in clinical volumes and provide standardized opportunities to achieve minimums. Longitudinal monitoring, stratified by program size, trainee leave, subspecialty focus, and institutional case mix, will help distinguish structural contributors

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from random variation, guide resource allocation, and detect emerging inequities, including potential gender differences, so that timely corrective actions can be implemented.

The ACGME “Floor” and Individual Competency

The near-universal attainment of ACGME minimums reflects the robustness of current monitoring systems. However, sources suggest that meeting minimums should not be conflated with the attainment of competency. In neurosurgery, most residents actually required more cases than the ACGME minimums to reach a “solo and observe” level of competency in complex procedures such as tumor resections or spinal fusions.¹⁵

Furthermore, the “floor effect” of minimum requirements may disincentivize accurate reporting when thresholds are not met. This was observed in orthopedic surgery, in which the implementation of case minimums was paradoxically followed by a decrease in total logged cases, suggesting that residents may stop logging elective procedures once they are no longer required for graduation.¹⁶

Differences in case logs during medical training are likely multifactorial, reflecting structural and behavioral influences rather than individual ability. Contributing factors include parental leave patterns, sorting into programs with different case mixes, rotation scheduling and workflow allocation, differential access to autonomy and mentorship, and variation in self-reporting or logging practices. Together, these elements can shape clinical exposure and documentation of cases, meaning that disparities in logged volumes often represent differences in training environment and reporting behavior rather than true differences in competency.^{17,18}

Although procedural case logs provide important information regarding clinical exposure, contemporary competency-based medical education frameworks emphasize that procedural volume alone is insufficient to determine readiness for independent practice. Programs

should, therefore, incorporate multiple complementary assessment modalities, including direct observation of procedural skills, workplace-based assessments, milestone evaluations, entrustable professional activities, simulation-based assessments, multisource feedback, and Clinical Competency Committee longitudinal reviews. These approaches allow programs to evaluate not only procedural participation but also decision making, technical proficiency, communication, professionalism, situational awareness, and the ability to independently manage complex perioperative care. In anesthesiology specifically, readiness for graduation may be better reflected by progressive entrustment and demonstration of consistent performance across clinical contexts rather than attainment of procedural minimums alone.¹⁹

Educational Implications for Program Design and Curriculum Development

The findings from this national analysis provide actionable insights for anesthesiology residency programs seeking to optimize training experiences and ensure equitable procedural exposure. Programs can use these benchmark data to evaluate their own case distributions against national trends, identifying categories in which residents may be underexposed or disparities by gender exist locally. For curriculum design, programs with lower than average volumes in specific categories, such as peripheral nerve blocks or pediatric cases, can strategically adjust rotation schedules to ensure adequate exposure, potentially extending the duration of subspecialty rotations or creating dedicated procedural clinics. The observed gender differences, though small in magnitude, suggest that program directors should monitor case distribution patterns within rotations and actively address potential barriers to equal participation, such as implicit biases in case assignment or differential self-selection into certain procedure types. Additionally, these data can inform the development of targeted simulation curricula to supplement clinical experience, particularly for high-stakes, lower volume procedures such as difficult airway management

or obstetric emergencies in which real-world exposure may be inconsistent. Programs transitioning to competency-based medical education can use these volume benchmarks as starting points for establishing meaningful entrustable professional activity thresholds while recognizing that case counts alone do not guarantee competence. Finally, rotation guides can be refined to include minimum case targets per rotation rather than relying solely on end-of-training totals, enabling earlier identification of trainees falling behind and allowing for proactive remediation strategies before graduation.

Limitations of Self-Reporting and Future Directions

The reliance on manual, self-reported logs remain a significant limitation. Studies have shown a 24.2% discordance between manual logs and institutional records, with junior residents often failing to log cases due to “poor recall” or the belief that a case was too minor to record.^{17,18}

An additional untested possibility is differential clustering of men and women across programs. We did not assess whether sex and case types are proportionally distributed within programs. If, for example, women are disproportionately matched to programs with lower overall case volume, we may be overlooking sorting in the match process as a contributing factor.

An important limitation is our inability to assess whether observed gender differences vary by program characteristics such as size, geographic location, or case mix. If female residents are disproportionately matched to programs with lower overall case volumes or concentrated in certain geographic regions, program-level factors rather than individual-level differences in case allocation could explain the observed disparities. Our data-use agreement did not permit program-level analyses that would allow us to explore these potential clustering effects.

To address these inaccuracies, there is an increasing push for automated electronic health record–integrated logging systems.²⁰ One such system demonstrated a 78% increase in captured procedures compared with manual logging, suggesting

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that current case logs significantly underrepresent actual trainee experience. As anesthesiology moves toward competency-based medical education, integrating high-fidelity, automated data will be essential to provide a more accurate picture of a resident's readiness for independent practice.^{14,21}

CONCLUSIONS

Procedural case volumes recovered following pandemic-related disruptions, whereas anesthesiology training continued to adapt to evolving clinical and educational demands throughout the pandemic period. The ACGME case log system effectively monitors program-level educational capacity with near-universal achievement of minimums demonstrating robust training infrastructure. However, the use of these program-monitoring tools for individual competency assessment, a purpose for which they were not designed, underscores the need for dedicated competency-based evaluation systems to assess individual readiness for independent practice.

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Abstract

Background: Whereas procedural volume has often been used as a proxy for experience, Accreditation Council for Graduate Medical Education (ACGME) case logs and minimum case requirements are designed primarily to document resident exposure and to help determine whether training programs provide sufficient breadth and volume of clinical experiences for their approved complement of residents. However, concerns persist regarding variability in clinical exposure across training institutions, the significant disruption to procedural training during the COVID-19 pandemic when elective cases were suspended nationwide, and potential gender-based differences in procedural experience as recent large-scale studies in general surgery, urology, and ophthalmology have consistently shown that female residents log significantly fewer cases than male residents. Contemporary national data describing anesthesiology case trends and equity across cohorts remain limited.

Methods: We conducted a retrospective descriptive cohort study of anesthesiology resident case logs across 5 graduating cohorts (2018–2019 through 2022–2023) from all ACGME-accredited programs in the United States. Deidentified resident-level procedural data were obtained from the ACGME case log system and linked to gender data from the Association of American Medical Colleges under a secure data-use agreement. Mean case volumes and 95% confidence intervals were calculated for major procedural categories. Independent-samples *t*-tests were used to compare case volumes by gender with effect sizes quantified using Cohen *d*. Minimum case requirement attainment was assessed across cohorts.

Results: Among 8879 residents (67% male, 33% female), 99.78% met all ACGME minimum requirements with no significant gender difference in compliance ($P = .086$). Case volumes declined during 2019–2020 but recovered by 2022–2023, consistently exceeding national minimums across all categories. Male residents logged significantly higher volumes overall and in specific categories (peripheral nerve blocks, cardiac, vascular, epidurals, life-threatening pathology) though effect sizes were small (Cohen *d*: 0.11–0.19). Gender differences in failing to meet minimum requirements were not statistically significant overall or within any individual procedural category (all P s > .05).

Conclusions: Anesthesiology residency training demonstrates remarkable resilience with near-universal achievement of procedural minimums despite pandemic disruptions. However, persistent gender-based differences in case volumes, coupled with known limitations of self-reported logging, highlight variability in residents' procedural exposure and reinforce the limitations of using case volume alone as a proxy for clinical competence. These findings support transitioning to automated data-capture methods that provide a more accurate and reliable measure of residents' procedural exposure, using competency-based assessments to determine clinical competence and readiness for independent practice.

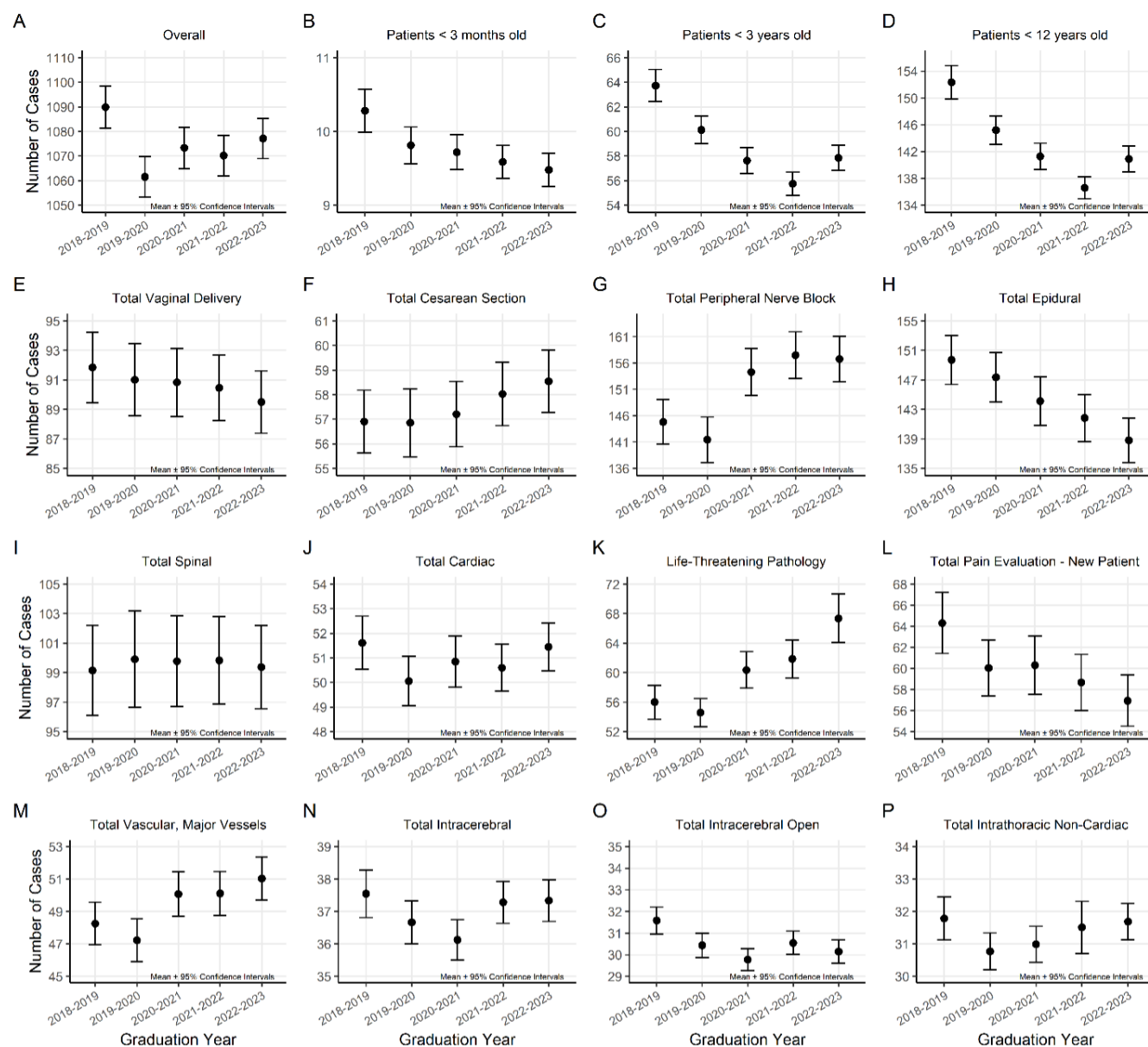
Keywords: Case logs; residency training; anesthesiology education

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Figures

Figure 1. Mean procedural case volumes across graduation cohorts, 2018–2019 to 2022–2023.



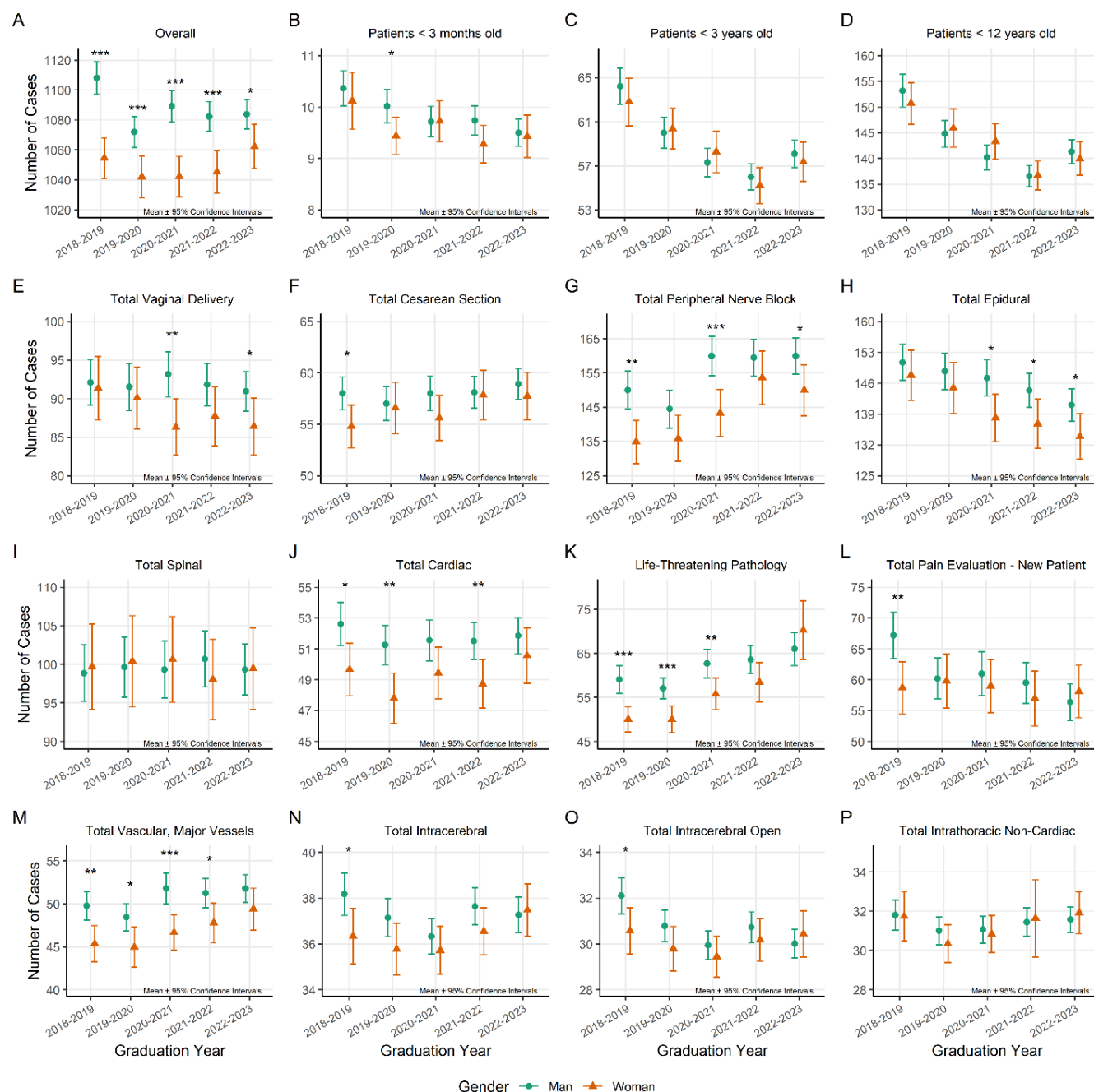
Note: Overall mean procedural case volumes increased 8.6% from 1,279 to 1,389 cases between 2018–2023, with most categories showing stable or increasing trends and no major COVID-19 pandemic-related disruptions.

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Figures

Figure 2. Procedural case volumes by gender across graduation cohorts, 2018–2019 to 2022–2023.



*P < 0.05; **P < 0.01; ***P < 0.001

Note: Male residents consistently logged significantly higher mean case volumes than female residents across all cohorts, with significant differences in 8 of 15 procedural categories, though both genders met ACGME minimum requirements at similar rates.

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Tables

Table 1. The Minimum Case Numbers and Mean Number of Cases per Trainee for Each Procedural Category Across the 5 Graduating Cohorts for Anesthesiology Procedures

Procedure Category	Minimum Number	Mean 2019	Mean 2020	Mean 2021	Mean 2022	Mean 2023
Life-threatening pathology	20	56.00	54.59	60.36	61.87	67.36
Patients <12 years old	100	152.33	145.19	141.27	136.59	140.89
Patients <3 months old	20	10.28	9.81	9.72	9.59	9.48
Patients <3 years old	5	63.73	60.13	57.61	55.73	57.85
Total cardiac	20	51.61	50.05	50.84	50.60	51.45
Total cesarean section	20	56.91	56.86	57.21	58.03	58.54
Total epidural	40	149.71	147.36	144.12	141.85	138.80
Total intracerebral	20	37.55	36.66	36.12	37.28	37.33
Total intracerebral open	11	31.58	30.43	29.78	30.55	30.14
Total intrathoracic noncardiac	20	31.78	30.77	30.99	31.51	31.69
Total pain evaluation–new patient	20	64.31	60.05	60.31	58.67	56.93
Total peripheral nerve block	40	144.82	141.45	154.30	157.51	156.76
Total spinal	40	99.15	99.91	99.77	99.83	99.37
Total vaginal delivery	40	91.84	91.01	90.83	90.45	89.50
Total vascular, major vessels	20	48.26	47.22	50.07	50.11	51.03

Note: https://www.acgme-i.org/globalassets/acgme-international/specialties/anesthesiology/040.anesth.case_log_information.pdf

Table 2. Number of Residents by Gender Across Five Graduation Cohorts in Anesthesiology Residency Programs from 2018 to 2023

Graduation Year	Total Number	Male n (%)	Female n (%)
2018-2019	1658	1093 (66)	565 (34)
2019-2020	1716	1114 (65)	602 (35)
2020-2021	1810	1199 (66)	611 (34)
2021-2022	1825	1224 (67)	601 (33)
2022-2023	1870	1281 (69)	589 (31)
Total	8879	5911 (67)	2968 (33)

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Tables

Table 3. Percentage Not Meeting Minimum Requirements by Category

Procedure	Male (67%)	Female (33%)	Overall (n = 8879)
Life-threatening pathology	0.27%	0.30%	0.28%
Patients <12 years old	0.58%	0.61%	0.59%
Patients <3 months old	0.36%	0.61%	0.44%
Patients <3 years old	0.03%	0.10%	0.06%
Total cardiac	0.08%	0.10%	0.09%
Total cesarean section	0.10%	0.03%	0.08%
Total epidural	0.05%	0.00%	0.03%
Total intracerebral	0.17%	0.27%	0.20%
Total intracerebral open	0.05%	0.10%	0.07%
Total intrathoracic noncardiac	0.44%	0.47%	0.45%
Total pain evaluation–new patient	0.32%	0.24%	0.29%
Total peripheral nerve block	0.15%	0.20%	0.17%
Total spinal	0.05%	0.20%	0.10%
Total vaginal delivery	0.24%	0.17%	0.21%
Total vascular, major vessels	0.12%	0.30%	0.18%
Overall	0.20%	0.25%	0.22%

Note: Minimum requirement based on ACGME. No statistically significant gender differences were observed in the rate of failing to meet minimum requirements within any individual procedural category.