

## ORIGINAL RESEARCH

# Hospital-Level Workforce and Capacity Factors Associated with Reported Anesthesiology Gross Revenue and Direct Expense in California Hospitals, 2023-2024

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## Academic Anesthesia

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Anesthesiology services are essential to hospital operations but can face growing workforce shortages amid the rising post-COVID-19 demand. This study uses the 2023–2024 California Hospital Annual Financial Disclosure dataset to examine the reported gross anesthesiology revenue and direct expenses across hospital systems. Regression analyses further examined the reported gross revenue and direct expenses. Gross revenue refers to the total revenue before deductions and should not be interpreted as net revenue, profit, collections, or contribution margins.

Reported gross revenue and direct expense were most strongly associated with workforce capacity and organizational scale. Residents, productive anesthesiology FTEs, and staffed beds emerged as significant predictors of gross revenue. Direct anesthesiology expenses were primarily associated with productive anesthesiology FTEs, while productive registered-nurse hours showed a statistically significant negative association after adjustment. Productive anesthesiology FTEs can be defined as the full-time and equivalent anesthesiology staff whose time is allocated to direct clinical service deliveries.

In contrast, measures of clinical complexity include anesthesia minutes, trauma designation, and specialization. The available hospital-level proxies for complexity were not independently associated with reported gross revenue or direct expense in these models. These findings support cautious use of hospital-level financial disclosure data for anesthesiology workforce planning, while underscoring the need for more granular case-mix, staffing-model, and clinical-outcome data.

## Introduction

For-profit hospital systems and even nonprofit healthcare organizations that must maintain operating margins all must work under a framework where reported gross revenue and direct expense become critical factors for sustainability. Anesthesiology as a service has been able to offer stable, predictable demands, as these services are seen as essential across all hospitals and ambulatory settings and procedures.<sup>1</sup>

However, during the post-COVID 19 era, the demand for anesthesia care is higher, especially in non-operating room settings. Notably, this has grown faster than the supply of anesthesiologists and registered nurses, which might have contributed to a workforce shortage. Because registered nurses constitute a substantial portion of the anesthesia workforce, particularly in team-based and rural practice models, understanding how anesthesia nursing resources contribute to organizational performance becomes increasingly important. This imbalance is found to be straining healthcare systems through increasing costs, worsening clinician burnout, disrupting surgical schedules, and can undermine academic training programs.<sup>2</sup> Projections as a result, can indicate shortages of more than 12,000 registered nurses and approximately 8,450 physician anesthesiologists by the years of 2033–2036.<sup>3</sup>

The State of California's Department of Health Care Access and Information provides open-access data from Hospital Annual Financial Disclosure Reports dating back to the year of 2012. This study has utilized the most recent 2023 and 2024 Fiscal Year Hospital Annual Financial Dataset.<sup>4</sup> It should be noted that the 2023–2024 hospital dataset did not contain repeated observations for the same anesthesia entities; therefore, each observation represented a unique entity, and duplicate records were not present in the analysis. Using this data, this study: 1) reviews how staffing and hospital capacity become associated with anesthesiology revenue, and 2) discusses the reported gross revenue and direct anesthesiology expenses across hospital systems.

## Literature Review

Demand for anesthesia care has grown faster than the supply of physician anesthesiologists and anesthesia nursing professionals, including CRNAs.<sup>5</sup> However, the present dataset captures registered-nurse productive hours within anesthesiology cost centers and cannot distinguish CRNAs from other nursing roles. Hua et al.'s (2025) study has found that when supported by proper data preparation, variable selection, and model validation, a regression becomes a useful tool for understanding specific clinical risks.<sup>6</sup> Efforts by the American Society of Anesthesiologists (ASA) have also further established additional rural pass-through payments through the Medicare Access to Rural Anesthesiology Act. The Act proposes supplemental funding for anesthesiology providers that are practicing in rural communities. Yet, this was unsuccessful during the congressional committee review in 2024.<sup>5,7</sup>

Federal funding reductions associated with H.R. 1 and the One Big Beautiful Bill Act can also be expected to significantly affect healthcare access. Of significance is that rural populations are likely to experience disproportionality.<sup>5</sup> According to KFF (formerly the Kaiser Family Foundation) in San Francisco, California, approximately one in four rural residents will depend on federally funded Medicaid for healthcare coverage.<sup>5</sup>

From a public choice perspective, large healthcare omnibus legislation does reflect policy bundling within institutional constraints, where coalition formation and logrolling enable the coordination of heterogeneous interests across multiple specialties and sectors within a single legislative framework.<sup>8</sup>

A sustainable approach to addressing the anesthesia supply and demand imbalance is to expand the number of anesthesiology residency training slots.<sup>2</sup> The distribution of CMS (Centers for Medicare and Medicaid Services) and funded residency slots under Section 126 of the Consolidated Appropriations Act (CAA) highlights a pivotal shift in how federal policy is addressing the physician shortage crisis. In anesthesiology, most of the Health Professional Shortage Area (HPSA) scores exceeded 14, indicating plausible evidence towards a substantial need for providers in these regions. However, the majority of Direct Graduate Medical Education (DGME) residency slots in anesthesiology were allocated to non-rural regions.<sup>9</sup> We then later examined the relationship between anesthesia resident staffing and gross patient revenue.

Abouleish et al. (2024) also argued that increasing anesthesia staffing ratios is often proposed to improve coverage and reduce costs; however, its benefits are uncertain and may even increase costs and patient risk.<sup>2</sup> Optimal staffing in this case, might depend further on patient complexity, procedure type, and site characteristics.<sup>2</sup> These obligations will necessitate a strong staffing team for stabilization and success with standardized care processes. Whitten et. al. (2023) does however, caution that because many non-anesthesiologist factors are associated with the number of anesthesia units billed, anesthesia unit totals as a result, become difficult to use for meaningful comparisons across individual clinicians. Most importantly, is the subspecialty teams within a group, or between different groups.<sup>10</sup> Calculations based on units billed resulted in higher productivity values for subspecialties with shorter surgical durations, and thus anesthesiology groups that take shorter cases measure higher productivity than those that take longer cases for the same hours of work.<sup>11</sup> Therefore, we proceed with examining productive anesthesiology FTEs as a key operational staffing measure, in addition to other predictors such as total anesthesiology minutes. FTEs are calculated by dividing the productive hours for each job classification by 2,080 hours and rounding the results to the nearest whole number. Every effort was made to ensure the accuracy of the data, calculations, and analyses presented in this manuscript; however, the possibility of inadvertent errors or omissions cannot be entirely excluded.

In addition to physician anesthesiologists, registered nurses represent a critical component of anesthesia service delivery. The dataset includes registered-nurse productive hours within anesthesiology cost centers, but it does not allow the authors to determine whether those hours reflect CRNAs, perioperative nursing support, or other anesthesia-related nursing labor.

Therefore, the workforce measures capturing anesthesia, nursing, and labor may provide further insight on service capacity, reported gross revenue, and direct expenses.

## Research Design

A regression analysis was found to be appropriate as a method for evaluating the relationship between the independent variables and the dependent outcome variable. This approach aims to determine the extent to which the predictor variables might contribute to the variability in the outcome of the two models.<sup>5</sup> Regression techniques first become utilized as a common method in quantitative research to allow the researcher to understand the magnitude, direction, and the statistical significance of the variables while still controlling for multiple predictors simultaneously.<sup>12</sup> This approach was deemed appropriate for our research questions.

We then analyzed the Hospital Annual Financial Disclosure Report - 2023 - 2024 Fiscal Year Hospital Annual Financial Data using 11 different variables. The variables were split into different predictors: 1) workforce predictors, 2) capacity predictors, 3) operation predictors, 4) institutional predictors, and 5) financial predictors. Workforce predictors included: 1) Anesthesia Residents, 2) Anesthesia FTEs, and 3) Anesthesia Board-Certified Staff. Capacity predictors included: 1) Staffed Beds and 2) Designated Trauma Center Levels. Operation predictors included: 1) Anesthesia Total Minutes, and 2) Anesthesia Units of Service. Institutional predictors included: 1) Emergency Services Trauma Treatment financial expenditure components were examined descriptively but excluded from the final direct-expense regression to avoid modeling total direct expense using its component costs.

### RQ1: Which staffing, hospital-capacity, and service-complexity measures are associated with reported anesthesiology gross revenue?

$$\begin{aligned}
 Y_{gross\ revenue} = & \beta_0 + \beta_1 \text{ anesthesia minutes} + \beta_2 \text{ productive FTEs} \\
 & + \beta_3 \text{ staffed beds} + \beta_4 \text{ residents} \\
 & + \beta_5 \text{ board certified staff} + \beta_6 \text{ ER trauma services} \\
 & + \beta_7 \text{ trauma center level} \\
 & + \beta_8 \text{ average hourly rate registered nurses anesthesiology} \\
 & + \beta_9 \text{ productive hours registered nurses anesthesiology} \\
 & + \epsilon
 \end{aligned}$$

### RQ2: Which workforce and capacity measures are associated with direct anesthesiology expenses?

$$\begin{aligned}
 Y_{total\ direct\ expenses} = & \beta_0 + \beta_1 \text{ staffed beds} + \beta_2 \text{ anesthesia total minutes} \\
 & + \beta_3 \text{ productive FTEs anesthesiology} \\
 & + \beta_4 \text{ productive hours registered nurses anesthesiology} \\
 & + \epsilon
 \end{aligned}$$

These variables were selected because they represent major dimensions of anesthesiology operations identified in prior workforce and hospital-finance literature. Workforce variables capture provider availability and labor capacity. Capacity variables reflect the institutional scale and the potential patient throughput. Operational variables measure service volume and clinical activity. Institutional variables account for differences in emergency and trauma-service responsibilities. Financial variables capture direct departmental expenditures associated with personnel, supplies, and contracted services.

## Findings

In the clinical and behavioral sciences, outcomes are often associated with a variation of psychological, biological, and environmental factors. The model fit was assessed utilizing the coefficient determination ( $R^2$ ), where a proportion of variance is represented through the dependent variable and explained by the independent variables in the model.<sup>13</sup> Significantly, higher ( $R^2$ ) values were still be found as a clinically important insight when interpreted in the appropriate research and depending on the clinical context.<sup>14</sup> In addition to the importance of examining the overall models and their fit, a regression analysis can support the hypothesis testing by evaluating whether the predictors are associated with the dependent variable. Such an approach can also allow researchers to better evaluate and examine the relative contribution of each variable while still accounting for any simultaneous effects. For this study, a regression analysis does provide robust support for statistical modeling and is appropriate for proceeding with the investigation. Multicollinearity was evaluated using variance inflation factors (VIFs). All VIF values were below 5, indicating that multicollinearity was not sufficiently severe to affect the stability or interpretation of the regression coefficients. This study aims to address any meaningful predictors within our applied research setting.

In the first research question, we asked how staffing, hospital capacity, and service complexity are associated with anesthesiology revenue ([Table 1](#)). We then estimated how staffing, hospital capacity, and service complexity might also be associated with the anesthesiology's total gross revenue. It should be noted that the regression models included additional institutional, hospital- and market-level control variables. To maintain the manuscript's conciseness, the coefficients for these variables are not presented. The complete regression output is available from the authors upon reasonable request. Payer mix (Medicare, Medicaid, Medi-Cal, and private insurance) was found to be not statistically significant and did not meaningfully alter the primary data estimates. Additionally, rural hospital status was also not found to be statistically significant and did not produce any meaningful changes to the primary estimates.

Table 1. Anesthesiology Revenue

| Regression Statistics |             |
|-----------------------|-------------|
| Multiple R            | 0.836336183 |
| R Square              | 0.699458211 |
| Adjusted R-Square     | 0.6895864   |
| Standard Error        | 61474186.39 |
| Observations          | 284         |

  

| ANOVA      |     |             |             |             |                |
|------------|-----|-------------|-------------|-------------|----------------|
|            | df  | SS          | MS          | F           | Significance F |
| Regression | 9   | 2.40987E+18 | 2.67763E+17 | 70.85409558 | 2.35493E-66    |
| Residual   | 274 | 1.03547E+18 | 3.77908E+15 |             |                |
| Total      | 283 | 3.44533E+18 |             |             |                |

  

|                                                                    | Coefficients | Standard Error | t Stat       | P-value | Lower 95%    | Upper 95%    |
|--------------------------------------------------------------------|--------------|----------------|--------------|---------|--------------|--------------|
| Intercept                                                          | -3634198.004 | 6334259.309    | -0.573736853 | 0.57    | -16104198.58 | 8835802.575  |
| Staffed Beds (Average)                                             | 179999.6065  | 48436.06863    | 3.716230727  | 0.00    | 84645.47365  | 275353.7394  |
| Designated Trauma Center Indicator Level 1, 2, 3, or 4             | -3970268.283 | 11716711.91    | -0.33885516  | 0.73    | -27036486    | 19095949.43  |
| Active Medical Staff Hospital-Based Board Certified Anesthesiology | 168442.7048  | 182927.273     | 0.920817886  | 0.36    | -191678.8324 | 528564.2421  |
| Residents Anesthesiology                                           | 3598907.705  | 691769.1372    | 5.202469309  | 0.00    | 2237049.732  | 4960765.678  |
| Emergency Services Trauma Treatment E.R.                           | -3106756.135 | 10259487.02    | -0.302817883 | 0.76    | -23304194.03 | 17090681.76  |
| Anesthesia Minutes Total Anesthesiology                            | 0.441034291  | 5.999666357    | 0.073509803  | 0.94    | -11.37026665 | 12.25233523  |
| Productive FTEs Anesthesiology                                     | 3527230.759  | 714831.721     | 4.934351198  | 0.00    | 2119970.409  | 4934491.109  |
| Average Hourly Rate Registered Nurses Anesthesiology               | 28685.99489  | 115831.3579    | 0.2476531    | 0.80    | -199346.5231 | 256718.5128  |
| Productive Hours Registered Nurses Anesthesiology                  | -1847.136891 | 533.087826     | -3.464976691 | 0.00    | -2896.605373 | -797.6684099 |

The analysis found that anesthesiology residents, average staffed beds, and productive anesthesiology FTEs were statistically significant predictors of gross patient revenue. We would like to note that a staffed bed in this case refers to a hospital bed that is licensed and physically available for patient care and the necessary clinical staff to provide services. Together, the findings represent statistical associations rather than causal effects. Findings here can also suggest that provider credentials alone may be less important to reported gross revenue and direct expense than the actual deployment of productive clinical labor as reflected by FTE measures. Productive registered-nurse hours were statistically significantly and negatively associated with reported gross revenue after adjustment; however, this finding should be interpreted cautiously because the variable may reflect heterogeneous nursing roles, institutional accounting practices, staffing-model differences, and multicollinearity with other workforce measures.

Although the dataset does not specifically identify registered nurses, anesthesia nursing labor likely reflects an important component of anesthesia care delivery and may capture differences in staffing models across hospitals. An analysis of various anesthesia staffing models showed that physician-to-nurse ratios significantly affect the cost-effectiveness of anesthesia care.<sup>15</sup>

Expanding anesthesiology residency positions, however, will still be challenging because effective training requires adequate exposure to complex surgical and anesthetic cases. Board-certified staff, anesthesia minutes, trauma center designation, and emergency trauma treatment services were not found to be statistically significant predictors in this model.

Staffed beds represent licensed and operational inpatient capacity. Anesthesia minutes measures cumulative anesthesia and service time. Productive FTEs represent clinically productive anesthesiology personnel. Average Hourly Rate Registered Nurses Anesthesiology represents the average hourly compensation paid to registered nursing personnel supporting anesthesiology services, including advanced-practice anesthesia nursing staff, where applicable. This variable serves as a measure of anesthesia-related nursing labor costs. Productive Hours Registered Nurses Anesthesiology represents productive hours reported for registered nursing personnel within anesthesiology cost centers. Because the dataset does not distinguish CRNAs from other nursing roles, this variable should be interpreted as a broad nursing labor measure rather than a provider-specific staffing variable. Because registered nurses frequently comprise a substantial portion of anesthesia nursing labor, this variable may also partially reflect the utilization of current nursing workforce resources within hospital anesthesiology departments. In the second research question, we examined the extent that productive registered nurse hours and FTEs become associated with direct anesthesia expenses ([Table 2](#)).

Table 2. Workforce and Capacity Factors Associated with Direct Anesthesia Expenses

| Regression Statistics                             |              |                |              |             |                |              |
|---------------------------------------------------|--------------|----------------|--------------|-------------|----------------|--------------|
| Multiple R                                        | 0.661467867  |                |              |             |                |              |
| R Square                                          | 0.437539739  |                |              |             |                |              |
| Adjusted R Square                                 | 0.42914481   |                |              |             |                |              |
| Standard Error                                    | 7056395.174  |                |              |             |                |              |
| Observations                                      | 273          |                |              |             |                |              |
|                                                   |              |                |              |             |                |              |
| ANOVA                                             |              |                |              |             |                |              |
|                                                   | Df           | SS             | MS           | F           | Significance F |              |
| Regression                                        | 4            | 1.03807E+16    | 2.59517E+15  | 52.11952656 | 1.93988E-32    |              |
| Residual                                          | 268          | 1.33444E+16    | 4.97927E+13  |             |                |              |
| Total                                             | 272          | 2.37251E+16    |              |             |                |              |
|                                                   |              |                |              |             |                |              |
|                                                   | Coefficients | Standard Error | t Stat       | P-value     | Lower 95%      | Upper 95%    |
| Intercept                                         | 284190.3025  | 676546.0056    | 0.420060573  | 0.67        | -1047830.801   | 1616211.406  |
| Staffed Beds_(Average)                            | -3339.01081  | 5318.704075    | -0.627786537 | 0.53        | -13810.76884   | 7132.747224  |
| Anesthesia Minutes Total Anesthesiology           | 0.981359693  | 0.610103826    | 1.608512604  | 0.11        | -0.21984638    | 2.182565767  |
| Productive FTEs Anesthesiology                    | 457813.6084  | 60780.0619     | 7.532299147  | 0.00        | 338146.4691    | 577480.7477  |
| Productive Hours Registered Nurses Anesthesiology | -140.6183604 | 56.77715794    | -2.47667135  | 0.01        | -252.4043615   | -28.83235928 |

The model demonstrated moderate explanatory power ( $R^2 = 0.437$ ), indicating that the included variables explained more than 43% of the variation in direct anesthesiology expenses. Productive anesthesiology FTEs were positively associated with direct anesthesiology expenses, whereas productive registered-nurse hours showed a statistically significant negative association after adjustment. This counterintuitive finding should be interpreted cautiously and may reflect collinearity, heterogeneous cost-center accounting, staffing-model differences, or residual confounding rather than a true cost-lowering effect. Findings suggest that departmental expenditures are associated primarily with labor deployment and operational spending rather than procedural volume alone.

Although the dataset does not specifically identify registered nurses, these findings are consistent with the expectation that anesthesia nursing labor represents a substantial component of departmental operating costs. Also, it should be explicitly noted that the study is limited by the available data, which do not allow for a meaningful comparison among physician anesthesiologists, anesthesia care-team models, and registered nurses. In contrast, staffed beds, anesthesia minutes, and average hourly nursing rates were not statistically significant predictors after controlling for the remaining variables. This study contributes to the growing literature around hospital organizational outcomes by examining workforce, operational, and broad financial factors; however, a few limitations are warranted for consideration. Together, these characteristics might affect organizational performance and lead to residual confounding. Future research areas should aim to incorporate these variables to analyze the robustness and generalization of the observed relationships. Despite the limitations addressed, the findings have provided insight into the factors associated with hospital performance and offer a fruitful foundation for future research inquiry.

## Conclusion

Overall, these results indicate that anesthesiology reported gross revenue, and direct expense were associated primarily with workforce structure and institutional scale rather than clinical complexity or service designations. Residents and productive anesthesiology FTEs, emerged as significant predictors of gross revenue, while direct expenses were most strongly associated with productive FTEs and productive registered nurse hours. Residents, in all specialties, contribute to gross revenue through direct federal GME funding and patient care, with one study showing that larger residency programs report higher revenues.<sup>16</sup> The strong association between productive FTEs and direct expenses is consistent with prior research showing that salary for patient care personnel accounted for over 50% of costs in hospital care.<sup>17</sup>

In contrast, measures of clinical complexity and specialization, including anesthesia minutes, trauma designation, and emergency trauma service, were not significant predictors of revenue or costs, suggesting limited reported gross revenue and direct expenses are associated once staffing and scale are accounted for.

The association between resident count and reported gross revenue may reflect broader teaching hospital characteristics, including institutional scale, case mix, and surgical volume. These findings support further study of how residency programs relate to hospital anesthesia capacity, but they should not be interpreted as evidence that adding residents directly increases revenue. Given ongoing shortages among both physician anesthesiologists and registered nurses, workforce planning strategies should focus on maximizing productive labor capacity while maintaining appropriate supervision and care-team structures. Importantly, our findings may have implications for physician anesthesiologists and hospital systems to advocate for adequate staffing levels, protected time and resources for resident education, and can aid understandings around sustainable call coverage structures. By situating the association between registered nurses and outcomes within complex hospital environments, the findings will also inform discussions on workforce planning and discussions around the resources needed to support patient care and medical education. Future research should aim to capture variables such as emergency case burden, surgical volume, teaching intensity, case acuity, procedure mix, non-operating room anesthesia, and inpatient versus outpatient mix.

We suggest further that the regression models can be re-estimated once post-implementation data from H.R. 1, the One Big Beautiful Bill Act, becomes available, specifically in the rural hospitals. This study is grounded in rational choice and public choice theory, which argues that policymakers design legislation in response to incentive structures, institutional constraints, and welfare-maximizing objectives.<sup>8, 18, 19</sup>

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