RESEARCH ARTICLE

More surgery in December among US patients with commercial insurance is offset by unrelated but lesser surgery among patients with Medicare insurance

Franklin Dexter[1] [ORCID] | Richard H. Epstein[2] | Christian Diez[2] | Brenda G. Fahy[3]

[1]Department of Anesthesia, University of Iowa, Iowa City, Iowa, USA

[2]Department of Anesthesiology, Perioperative Medicine and Pain Management, University of Miami Miller School of Medicine, Miami, Florida, USA

[3]Department of Anesthesiology, University of Florida College of Medicine, Gainesville, Florida, USA

Correspondence
Franklin Dexter, Department of Anesthesia, University of Iowa, 200 Hawkins Drive, Iowa City, IA 52242, USA.
Email: Franklin-Dexter@UIowa.edu

Abstract

Study Objective: Evaluate whether there is more surgery (in the US State of Florida) at the end of the year, specifically among patients with commercial insurance.

Design: Observational cohort study.

Setting: The 712 facilities in Florida that performed inpatient or outpatient elective surgery from January 2010 through December 2019.

Results: Among patients with commercial insurance, December had more cases than November (1.108 [1.092–1.125]) or January (1.257 [1.229–1.286]). In contrast, among patients with Medicare insurance (traditional or managed care), December had fewer cases than November (ratio 0.917 [99% confidence interval 0.904–0.930]) or January (0.823 [0.807–0.839]) of the same year. Summing among all cases, December did not have more cases than November (ratio 1.003 [0.992–1.014]) or January (0.998 [0.984–1.013]). Comparing December versus November (January) ratios for cases among patients with commercial insurance to the corresponding ratios for cases among patients with

Medicare, years with more commercial insurance cases had <u>more</u> Medicare cases (Spearman rank correlation +0.36 [+0.25], both *p* < 0.0001).

Conclusions: In the US State of Florida, although some surgeons' procedural workloads may have seasonal variation if they care mostly for patients with one category of insurance, surgical facilities with patients undergoing many procedures will have less variability. Importantly, more commercial insurance cases were not causing Medicare cases to be postponed or vice-versa, providing mechanistic explanation for why forecasts of surgical demand can reasonably be treated as the sum of the independent workloads among many surgeons.

KEYWORDS

anaesthesia, anaesthesiology, managerial epidemiology, operating room management, surgery, time series analysis

Highlights

- In US State of Florida, patients with commercial insurance had more surgery in December
- Patients with US Medicare insurance had less surgery in December than other months
- Years with more commercial insurance cases in December had more US Medicare cases too
- Implication for surgical suites: busier months for some patient groups balanced by less busy for others

1 | INTRODUCTION

Studies have detected little potential benefit from anaesthesia and operating room nurse staff scheduling being adjusted based on the month of the year, because there has been at most small variations in elective (scheduled) surgery.[1,2] For example, at a large United States (US) teaching hospital, workloads among series of 12 four-week periods from 1994 to 1997 and from 2005 through 2017 followed normal distributions without one period systematically being larger or smaller than others.[1,2] Similarly, at a different large teaching hospital, from 1989 through 1995, there were dominant periodic components from day of the week and annual holidays, but not from seasons of the year.[3] Nationwide in the USA, 1994–1996, there was no significant variation among successive four-week periods in ambulatory surgery cases.[4]

However, the generalisability of these earlier findings is unknown. From the 1994 to 1996 US national survey, there was substantial seasonal variation in myringotomy tube placement.[4] Thus, presumably, the absence of seasonal variation in overall surgical caseload was caused by there being some elective procedures performed more commonly during the summer than during the winter, and some the opposite, resulting in caseloads averaging out.[4] However, that national survey had insufficient sample sizes for other potentially seasonal procedures, and the sample design

prohibited valid analysis by facility.[4,5] One goal of our study was to evaluate whether seasonal variation related to the end of the calendar year needs to be considered when calculating staffing during regular operating room work hours.

Recent data suggests there may be substantial seasonal variation for elective surgery in the USA based on payer. From the US National Inpatient Sample, some common procedures were performed more often in December than other months among patients with commercial insurance, and the opposite among patients with Medicare.[6] Also from the National Inpatient Sample, posterior lumbar fusion was performed more often during the fourth quarter of each year among patients with commercial insurance.[7]

In the current study, we used 10 consecutive years (2010–2019) of surgical data from every non-federal surgical facility in the US State of Florida. We measured the heterogeneity among months in caseload for elective surgery. To examine the end of the year effect for commercial insurance, we then compared pairwise by year November to December (1-month apart) and January to December (11-month apart), controlling for facility and category of procedure. If cases of these different primary payers changed differentially among months, our goal would be to evaluate the extent to which more cases among patients with commercial insurance could have caused postponement of surgical cases among older patients with Medicare insurance.

2 | METHODS

2.1 | Ethics

Our dataset included all 57,786,140 patient encounters at all 750 non-federal ambulatory surgical facilities and hospitals in Florida between 1 January 2010, and 31 December 2019. These are data publicly available from the Agency for Health Care Administration (AHCA) supplemented by special request with the dates of each encounter (for ambulatory patients) or the date of admission (for inpatients). Provision of the specific dates was made subject to data use agreements between the University of Florida, AHCA, and the University of Miami. Facilities were deidentified before analysis. The Institutional Review Boards of the University of Miami and the University of Florida approved this project as non-human subjects research and as exempt, respectively. AHCA disclaims responsibility for the results and conclusions of this study of seasonality.

2.2 | Data from State of Florida

There were 30,183,592 ambulatory database records, each with 1 to 30 Current Procedural Terminology codes. We found the intraoperative work relative value units for each procedure using the 2021 National Physician Fee Schedule Relative Value File January Release.[8] We found the base units for each procedure using the American Society of Anaesthesiologists' (ASA) CROSSWALK 2020 file.[9] We excluded 17,442,577 records with zero intraoperative work relative value units or zero American Society of Anaesthesiologists' base units because such procedures generally do not involve use of an operating room. That left 12,741,015 ambulatory surgery cases. We selected the Current Procedural Terminology code with the most intraoperative work relative value units as the principal procedure.[10-12] We excluded cases performed on Saturdays and Sundays. The 82 days with fewer than 1500 ambulatory cases statewide were days with hurricanes in Florida, federal holidays, or dates that were one day before or after federal holidays. Dropping these 3.16% of non-weekend days, we analysed 12,667,510 ambulatory surgery cases (Table 1).

There were 27,602,548 patient admissions. We excluded admissions with emergency room charges, not listed as elective, or without the discharge's listed principal procedure having been performed on the date of admission.[13] That left 3,116,234 admissions. We excluded the 578,069 records with the principal procedure code neither a major therapeutic nor major diagnostic procedure,[14,15] resulting in 2,538,165 inpatient surgical cases. The reason for this

TABLE 1 Characteristics of the studied N = 15,164,158 cases at 19,216 facilities × years[a]

Principal payer	Ambulatory N = 12,667,510 cases	Inpatient N = 2,496,648 cases	Combined N = 15,164,158 cases
Medicare: includes medicare managed care plans[b]	43.3% (5,485,636/12,667,510)	48.2% (1,202,384/2,496,648)	44.1% (6,688,020/15,164,158)
	43.8% (40.9%–46.6%) among the 15,605 Facility × years with at least 100 cases	48.3% (44.7%–51.9%) among the 5305 Facility × years with at least 100 cases	44.5% (41.8%–47.1%) among the 15,632 Facility × years with at least 100 cases
	Intraoperative work relative value units 41.7% (39.2%–44.2%)		
Commercial: includes private managed care plans[b]	40.3% (5,101,494/12,667,510)	35.1% (875,597/2,496,648)	39.4% (5,977,091/15,164,158)
	40.3% (38.5%–42.2%)	35.1% (32.6%–37.5%)	39.5% (37.7%–41.2%)
	Intraoperative work relative value units 42.3% (40.4%–44.1%)		
Any payer:	Cases 100% (all)	Cases 100% (all)	Cases 100% (all)
Includes medicare, commercial, patient self-pay, workers' compensation	Mean 6.61 intraoperative work relative value units per case (standard deviation 3.98)		

[a]There are 712 facilities with at least 1 elective surgical case.

[b]The 99% confidence intervals were calculated using the analyses of ratios of the totals among the 10 years, limited to the Facility × Years with at least 100 cases, with robust variance estimation calculated with clustering by facility. These intervals match how the confidence intervals in the Results were calculated. These intervals are included in this table to assure that even when the narrowest from including all data they include the true values. Accurate coverage was expected because the cases of each Facility × Year (N = 15,632) and denominators of each facility (N = 629 clusters) are positively correlated (Spearman 0.57, Pearson 0.67) and the denominator has many degrees of freedom.[17]

exclusion was that minor procedures are typically performed outside of an operating room. Excluding those with date of admission on Saturday, Sunday, Hurricane, or holiday, 2,496,648 cases were analysed (Table 1).

2.3 | Statistical analyses

Ratios of total cases between months (e.g., December/November) were analysed because totals could be decomposed into the categories of Medicare, commercial, or another payer (Table 1). Our primary focus was the association between monthly ratios of Medicare and commercial payers. Pairwise ratios were used because of nonlinear growth in surgery among years. We compared December pairwise both to the nearest month (November) and to the farthest (January) month of the same year, such that any effect of patients' deductible or annual tax-free spending accounts that may influence timing of surgery in November and December would be fully unknown in the preceding January of the year.

Spearman rank correlation coefficients were calculated by Facility × Year and by Year (i.e., pooled among facilities) (STATA 17.0 *spearman* command [StataCorp, College Station, Texas]). The *p*-values and 99% confidence intervals (CIs) were two-sided.

Although we studied the entire population of surgical cases performed at non-federal facilities in Florida 2010–2019, we calculated CI for the ratios of total cases and of intraoperative work relative value units between months.

We did so to assess precisions of these summary measures (e.g., to know what differences in the ratios should be treated as generalisable for management decision-making by facilities outside of Florida). The STATA *ratio* command estimated the variance using the delta method.[16,17] We used robust clustering by facility. Clusters were limited to those with at least 100 observations in both months; there was not residual association between variability and case-loads (Figure 1).[18] We repeated calculations without clustering by facility (i.e., just with $N = 10$ years) and with clustering by procedure category[10-12]; however, those results were restricted to Tables 2 and 3 because ratios do differ among facilities (Figure 1) and different procedures' caseloads at the same facility may be correlated. Every confidence interval with these two alternative approaches overlapped with the corresponding point estimate obtained while clustering by facility, and every CI obtained while clustering by facility included the other point estimates (Tables 2 and 3).
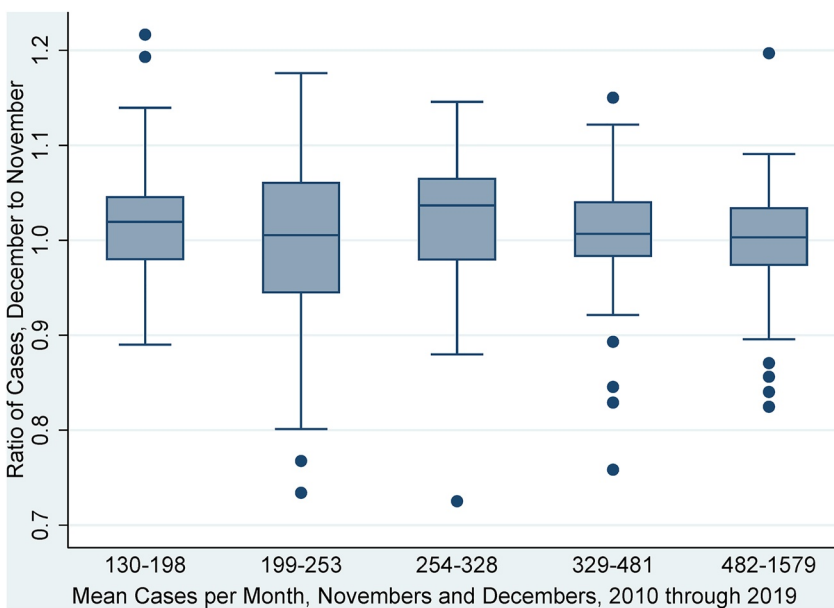

FIGURE 1 Box plots showing variability among facilities in ratios of total cases (ambulatory and inpatient) between Decembers and Novembers, during the period between 2010 through 2019. This figure supplements our primary analyses that are stratified by facility. That approach depends on being able to measure the ratios accurately then by facility. We therefore limit consideration to facilities with at least 100 cases in each studied month. Specifically, among the overall $N = 15,164,158$ cases, there were 1,242,797 and 1,241,500 cases during months of December or November, respectively. Among the 269 facilities each with at least 100 cases for all December and November for all 10 years, the cases (included in the current figure) were 985,180 and 981,586, respectively. For each of the 269 facilities, the total count of cases over the 10 December and 10 November was summed, and then divided by 20 months. The five quintiles of those months are shown along the horizontal axis of the figure. There was considerable variability among facilities in the ratios. However, the homogeneity of the box plot among the quintiles shows that the heterogeneity of ratios among facilities is not due to heterogeneity in sample size (e.g., our threshold's use of at least 100 cases per month). Levene's robust test statistics show that we can reasonably assume equality of variances ($p = 0.16$ based on mean, $p = 0.17$ based on median, and $p = 0.16$ based on 10% trimmed mean) (rsdtest) [Colour figure can be viewed at wileyonlinelibrary.com]

TABLE 2 Analyses of cases in the same sequence as in the Results section

Insurance	Month compared pairwise to December	Clustering (# clusters)[a]	N	Ratio December to compared month (99% confidence interval) [ratios >1 and ratios <1]
Medicare	November	Facility (238)	1634 facility × years	0.917 (0.904–0.930)[b]
		Procedure (73)[a]	627 procedure × years	0.911 (0.893–0.929)
		None (0)	10 Years	0.911 (0.841–0.982);[c]
				2 ratios >1 and 8 ratios <1[d]
	January	Facility (234)	1644 facility × years	0.823 (0.807–0.839)[e]
		Procedure (71)[a]	629 procedure × years	0.817 (0.766–0.867)
		None	10 years	0.817 (0.759–0.876);[f]
				0 ratios >1 and 10 ratios <1[d]
Commercial	November	Facility (243)	1575 facility × years	1.108 (1.092–1.125)[b]
		Procedure (75)[a]	691 procedure × years	1.113 (1.062–1.164)
		None	10 Years	1.112 (1.040–1.184);[c]
				10 ratios >1 and 0 ratios <1[d]
	January	Facility (195)	1299 facility × years	1.257 (1.229–1.286)[e]
		Procedure (72)[a]	657 procedure × years	1.294 (1.211–1.377)
		None	10 Years	1.129 (1.200–1.385);[f]
				10 ratios >1 and 0 ratios <1[d]
Any	November	Facility (461)	3623 facility × years	1.003 (0.992–1.014)[g,h]
		Procedure (106)[a]	963 procedure × years	1.001 (0.956–1.047)
		None	10 Years	1.001 (0.932–1.070);[g]
				5 ratios <1 and 5 ratios >1[d]
	January	Facility (437)	3531 facility × years	0.998 (0.984–1.013)[h]
		Procedure (106)[a]	952 procedure × years	0.999 (0.952–1.046)
		None	10 Years	0.999 (0.929–1.068);
				4 ratios >1 and 6 ratios <1[d]

[a]The principal procedure was converted to the Agency for Healthcare Research and Quality's Clinical Classifications Software category of procedure.[10–12]

[b]Compare pairwise the N = 903 years × facility combinations each with at least 100 cases for both December and November. There was positive correlation between cases with Medicare and cases with commercial payers (Spearman 0.36, $p < 0.0001$).

[c]Compare pairwise the N = 10 years of December versus November ratios for cases among patients with Medicare to the N = 10 years of December versus November ratios for cases among patients with commercial insurance. There was positive correlation (Spearman 0.94, $p = 0.0001$). Among the N = 15,164,158 cases (inpatient or ambulatory), there were 1,145,480 and 1,143,109 cases during months of December or November, respectively.

[d]The counts of the N = 10 ratios >1 and < 1 correspond to the sign test, or Wilcoxon signed-ranks test. If there were 5 ratios >1 and 5 ratios <1, then the overall ratio would be approximately equal to 1. When 10 ratios >1 and 0 ratios <1, the overall ratio would reliably be > 1 ($p < 0.0001$ by sign test or Wilcoxon signed-ranks test).

[e]Compare pairwise the N = 806 years × facility combinations each with at least 100 cases for both December and January. There was positive correlation (Spearman 0.27, $p < 0.0001$).

[f]Compare pairwise the N = 10 years of December versus January ratios for cases among patients with Medicare to the N = 10 years of December versus January ratios for cases among patients with commercial insurance. There was absence of negative correlation (Spearman 0.68, $p = 0.029$; Pearson 0.74, $p = 0.0145$). There were 1,145,480 and 1,121,741 cases during months of December or January, respectively.

3 | RESULTS

3.1 | Graphical, qualitative description of observations

Over the 10 years, there were progressively more cases among patients both with Medicare insurance and with commercial insurance (Figure 2).

There were fewer surgical cases among patients with Medicare insurance in December than November (Figure 3). There were more surgical cases among patients with commercial insurance in December than November (Figure 3). These two observations are quantified in the first and second paragraphs of Section 3.2, respectively.

The yearly ratios were positively correlated (i.e., years with more commercial cases in December vs. November also had more Medicare cases in December vs. November) (Figure 3). This observation is quantified below in Section 3.3.

The resulting ratios of December to November overall caseloads and intraoperative work relative value units were close to 1 (Figure 4). In terms of total caseload, December was similarly, and reliably, no busier than other months (Figure 5). These observations are quantified in Section 3.4.

3.2 | December versus November and December versus January, by payer

Among patients with Medicare insurance (traditional or managed care), December had fewer cases than November (ratio 0.917 [CI 0.904–0.930], Table 2) and fewer intraoperative work relative value units (ratio 0.921 [0.906–0.936], Table 3). December had also fewer cases than the preceding January (0.823 [0.807–0.839]) and fewer intraoperative work relative value units (0.832 [0.814–0.850]).

Among patients with commercial insurance, December had more cases than November (1.108 [1.092–1.125], Table 2) and more intraoperative work relative value units (1.122 [1.105–1.138], Table 3). December also had more cases than the preceding January (1.257 [1.229–1.286]) and more intraoperative work relative value units (1.297 [1.264–1.329]).

3.3 | Variations among months in cases with Medicare versus commercial insurance

We compared pairwise the December versus November ratios for cases among patients with Medicare to the corresponding ratios for cases among patients with commercial insurance. There was significant positive correlation by cases (Spearman 0.36, $p < 0.0001$, Table 2) and by intraoperative work relative value units (Spearman 0.30, $p < 0.0001$,

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[g]The confidence intervals (0.992–1.014) were considerably narrower with clustering by facility than without clustering; see two rows later in the table, 0.932–1.070. The intervals were narrower in part because the functional sample size was so much larger. To assess, we repeated with the 3623 facility × year observations but without clustering. The point estimate was the same (1.003), but with narrower confidence interval 0.997–1.010, as expected. The estimated standard error was 39.7% smaller. To also assure that analyses were performing as expected, we used mixed effects modeling with facility as a random effect. The mean of the ratios (point estimate 1.016 [1.006–1.028]) gave significantly different estimates ($p = 0.0009$) than the ratio of the means. That mean of the ratios is biased, given that its 99% confidence interval does not include 1.002, the ratio of the total over all 10 years of the cases performed anywhere statewide in December (1,145,580) divided by the corresponding total of the cases performed in November (1,143,109).

[h]As context to the 1.003 ratio for December versus November, among the 3623 Facility × Years, there were 26% (947) with December cases at least 10% greater than November versus 21% (757) the opposite. As context to the 0.998 ratio for December versus January, there were 31% (1091) with December cases at least 10% greater than January versus 27% (970) the opposite. These calculations neglect the variability of magnitudes among facilities and unequal numbers of years among facilities.

TABLE 3 Analyses of intraoperative work relative value units in the same sequence as in the Results section

Insurance	Month compared pairwise to December	Clustering (# clusters)[a]	N	Ratio December to compared month (99% confidence interval) [ratios >1 and ratios <1]
Medicare	November	Facility (238)	1634 facility × years	0.921 (0.906–0.936)[b]
		Procedure (73)[a]	627 procedure × years	0.915 (0.894–0.936)
		None (0)	10 Years	0.915 (0.842–0.988);[c]
				2 ratios >1 and 8 ratios <1[d]
	January	Facility (234)	1644 facility × years	0.832 (0.814–0.850)[e]
		Procedure (71)[a]	629 procedure × years	0.820 (0.781–0.859)
		None	10 years	0.821 (0.761–0.881);[f]
				0 ratios >1 and 10 ratios <1[d]
Commercial	November	Facility (243)	1575 facility × years	1.122 (1.105–1.138)[b]
		Procedure (75)[a]	691 procedure × years	1.124 (1.075–1.172)
		None	10 Years	1.124 (1.052–1.195);[c]
				10 ratios >1 and 0 ratios <1[d]
	January	Facility (195)	1299 facility × years	1.297 (1.264–1.329)[e]
		Procedure (72)[a]	657 procedure × years	1.326 (1.232–1.420)
		None	10 Years	1.326 (1.237–1.416);[f]
				10 ratios >1 and 0 ratios <1[d]
Any	November	Facility (461)	3623 facility × years	1.016 (1.005–1.028)[g]
		Procedure (106)[a]	963 procedure × years	1.013 (0.965–1.061)
		None	10 Years	1.014 (0.943–1.084);
				7 ratios <1 and 3 ratios >1[d]
	January	Facility (437)	3531 facility × years	1.029 (1.012–1.046)[g]
		Procedure (106)[a]	952 procedure × years	1.028 (0.966–1.089)
		None	10 Years	1.028 (0.959–1.098);
				7 ratios >1 and 3 ratios <1[d]

[a]The principal procedure was converted to the Agency for Healthcare Research and Quality's Clinical Classifications Software category of procedure.[10–12]

[b]Compare pairwise the N = 903 years × facility combinations each with at least 100 cases for both December and November. There was positive correlation between intraoperative work relative value units among cases with Medicare and commercial payers (Spearman 0.30, $p < 0.0001$).

[c]Compare pairwise the N = 10 years of December versus November ratios for work relative value units among patients with Medicare to the N = 10 years of December versus November ratios for work relative value units among patients with commercial insurance. There was positive correlation (Spearman 0.96, $p = 0.0001$). Among the N = 15,164,158 cases (inpatient or ambulatory), there were 1,145,480 and 1,143,109 cases during months of December or November, respectively.

[d]The counts of the N = 10 ratios >1 and < 1 correspond to the sign test, or Wilcoxon signed-ranks test. If there were 5 ratios >1 and 5 ratios <1, then the overall ratio would be approximately equal to 1. When 10 ratios >1 and 0 ratios <1, the overall ratio would reliably be > 1 ($p < 0.0001$ by sign test or Wilcoxon signed-ranks test).

[e]Compare pairwise the N = 806 years × facility combinations each with at least 100 cases for both December and January. There was positive correlation (Spearman 0.31, $p < 0.0001$).

[f]Compare pairwise the N = 10 years of December versus January ratios for work relative value units among patients with Medicare to the N = 10 years of December versus January ratios for work relative value units among patients with commercial insurance. There was absence of negative correlation (Spearman 0.71, $p = 0.022$; Pearson 0.68, $p = 0.029$). There were 1,145,480 and 1,121,741 cases during months of December or January, respectively.
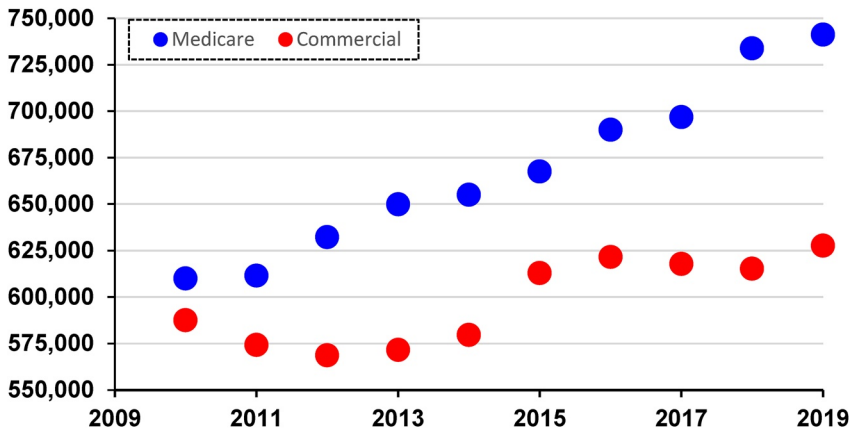
FIGURE 2 Increases in caseload over the 10 studied years. There was a monotonic increase in the numbers of cases studied among patients with Medicare insurance (Spearman correlation 1.00, $p < 0.0001$). There was a progressive but not monotonic increase in the cases among patients with commercial insurance (Spearman correlation 0.79, $p = 0.0061$). The Spearman correlation coefficient among all types of surgery, irrespective of primary payer, was 0.98 [Colour figure can be viewed at wileyonlinelibrary.com]

Table 3). There also was significant positive correlation pairwise between the December versus January ratios, by cases (Spearman 0.27, $p < 0.0001$) and by intraoperative work relative value units (Spearman 0.31, $p < 0.0001$). Thus, Medicare cases were not deferred to create openings for patients with commercial insurance, or vice-versa. The different populations of patients with different payers had different distributions of caseload (and workload) among months, conveniently offsetting one another.

3.4 | Distribution of caseload and workload among months, without regard to type of insurance

The ratio of total cases in December versus November did not differ significantly from 1.0 (ratio 1.003 [0.992–1.014]), nor did the ratios of total cases in December versus January (0.998 [0.984–1.013]) (Table 2). The ratios for intraoperative work relative value units were slightly greater than one, both for December versus November (1.016 [1.005–1.028]) and December versus January (1.029 [1.012–1.046]) (Table 3).

3.5 | Other analyses

Figure 6 presents the results of Table 2, but with each month's count of cases and intraoperative work relative value units divided by the month's workdays (see Limitations).

We evaluated whether individual facilities can reliably examine the studied patterns by category of procedure between November and December from their own case logs, for potential use in evaluating their surgeons and their practices. Among the 49,128 combinations of facility and CCS procedure category in the entire state, there were just 2 codes present in both in December and November for each of the 10 years and at with at least 100 cases among

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gAs context to the 1.016 ratio for December versus November, among the 3623 Facility × Years, there were 32% (1146) with December work relative value units at least 10% greater than November versus 22% (809) the opposite. As context to the 1.029 ratio for December versus January, there were 38% (1338) with December work relative value units at least 10% greater than January versus 26% (909) the opposite.
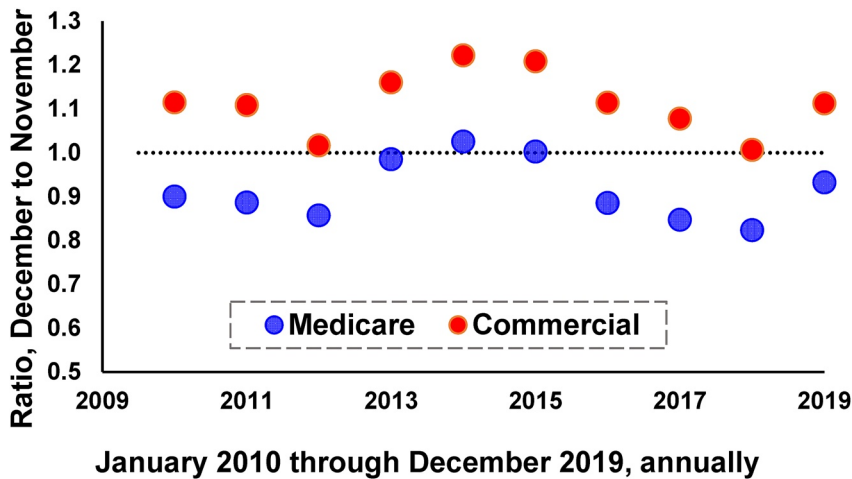
FIGURE 3 Ratios of the total cases, ambulatory or inpatient, in December divided by those in November, calculated once among patients with Medicare insurance and once among patients with commercial insurance. Confidence intervals are not included because the figure shows the raw estimates, without adjustment for facilities or procedures, unlike in Table 2. The circles are drawn large obscuring the perspective, but from Table 2 there are 8 ratios <1 among patients with Medicare insurance and 10 ratios >1 among patients with commercial insurance. The positive correlation coefficients between the Medicare and commercial insurance $N = 10$ observations were 0.93 for Spearman and 0.94 for Pearson (see Section 3.3 for inferential analyses). The corresponding correlation coefficients for intraoperative work relative value units were 0.96 for Spearman and 0.94 for Pearson. To make comparison with the point estimates in Table 2, among patients with commercial insurance as payer, the ratio of the total over all 10 years of the cases in December (567,089) divided by the corresponding total of the cases performed in November (509,935) equals 1.112. The point estimates are 1.108 to 1.013, with all 99% confidence intervals including 1.112. Among patients with Medicare as payer, total cases in December (488,776) divided by November (536,336) equals 0.911. The point estimates in Table 2 are 0.911–0.917, again with the 99% confidence intervals all including 0.911 [Colour figure can be viewed at wileyonlinelibrary.com]

patients with Medicare and 100 cases among patients with commercial insurance. The studied categories were both CCS = 15, 'lens and cataract procedures.' Neither facility had more cases among patients with commercial insurance: ratios 1.023 ($p = 0.52$) and 0.905 ($p = 0.16$), respectively. These findings suggest futility for organisations to rely on local data or impressions of relative workloads among months based on payer.

We examined changes over years in the percentages of total cases in December among patients with commercial insurance versus patients with Medicare.[19] For example, in 2010, 45% of cases were among patients with commercial insurance and 42% of intraoperative work relative value units. In comparison, in 2019, these percentages were 48% by cases and 44% by work relative value units. The Spearman correlation coefficients with $N = 10$ years were 0.37 ($p = 0.29$) and 0.16 ($p = 0.65$), respectively.

4 | DISCUSSION

Allocating future operating room and anaesthesia time depends fundamentally on time series analyses, and then selecting an expected percentile of the forecasted probability distribution of workload.[20] This process is important to reduce the hours that nurses, anaesthesiologists, nurse anaesthetists, etc., work late, while assuring patients prompt access to surgery.[21,22] In the current paper, we considered the forecasting,[1–4] on a monthly time-scale.[23] As hypothesised based on national survey nearly 2 decades ago,[4] overall surgical workload had small variation among months
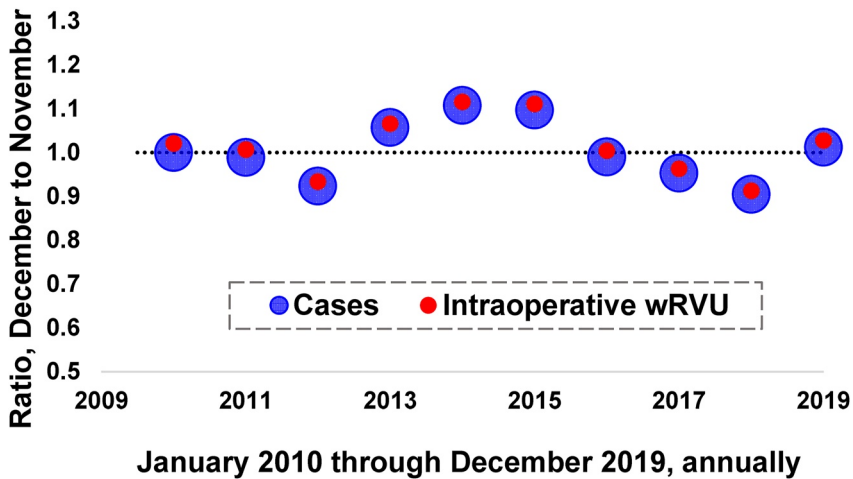
FIGURE 4 Ratio of total (ambulatory and inpatient) cases and (ambulatory) intraoperative work relative value units (wRVU) for each December relative to the corresponding November. Confidence intervals are not provided because the figure shows the raw estimates, without adjustment for facilities or procedures, unlike in Tables 2 and 3. There are overall 1,242,797 cases during the Decembers and 1,241,500 cases during the Novembers, the ratio being 1.001. From Table 2, pooling among years, the 99% confidence interval for the ratio of 1.001 equals 0.932–1.070, $p = 0.96$ versus 1.00. The circles are drawn large obscuring the perspective, but there are 5 blue circles greater than 1.00 and 5 less than 1.00. This analysis by case includes not only ambulatory surgery but also inpatient surgery. From Table 3, the ratio for intraoperative work relative value units equals 1.014 (0.943–1.084), $p = 0.54$. There are 7 red dots greater than 1.00 and 3 less than 1.00. Larger ratios for intraoperative work relative value units would be expected because the procedures of commercial insurance with more cases in December are fully ambulatory surgery (see last paragraph of Results); the intraoperative work relative value units are limited to ambulatory surgery. The circles overlap on the graph, but 10 of the 10 ratios were larger pairwise by year for intraoperative work relative value units than for cases, although seemingly of such minor differences as to be irrelevant managerially as compared to the differences between Medicare and commercial (Figure 2) [Colour figure can be viewed at wileyonlinelibrary.com]

because increases in some patient groups are balanced by decreases in others (Tables 2 and 3). When planning staffing, the strategy of not including seasonal variation[1,2,4] was supported, and the reasons for the result elucidated.

The incremental knowledge from the current study includes that we can reject the hypothesis of competition for available operating room time causing this behaviour (i.e., years with greater than typical increases in commercial cases reliably were not associated with greater declines in Medicare cases). There are the commercial cases and the Medicare cases, both get done, and, conveniently, seasonal variation in each somewhat cancel out (Tables 2 and 3). Statistically speaking, workload was the cumulative offsetting effect of the summation of different time series. This finding is important because it supplies added evidence that, in practice, the monthly clinical surgical demand is being met by surgical facilities[24]; otherwise, the correlation would have been significantly negative, not reliably positive by year. We similarly found previously that, throughout the State of Iowa, caseloads were limited by surgeons' schedules, not by operating room or anaesthesiologists' availability.[24] That conclusion was based on there being fewer cases during national surgical meetings but not during anaesthesia meetings.[24] Based on time series from one large teaching hospital, long-term growth in caseloads was managed both by having more first case starts (operating rooms) and by working longer hours.[25] Why capacity can be adjusted to demand at a statewide level also is understood.[26-29] Both for Iowa and for Florida, studying all surgical cases at all non-federal facilities, most surgeons' daily elective lists have only one or two cases.[26,27] Furthermore, those are the surgeons responsible for most of the growth in surgery from 1 year to the next, averaging two or fewer cases per week.[28,29] Thus, surgical growth is ensured principally by facilitating the scheduling of single extra cases by surgeons not otherwise operating (i.e., without other surgical constraints).[28,29] Consequently, facilities can realise the greater surgical demand, and then progressively increase
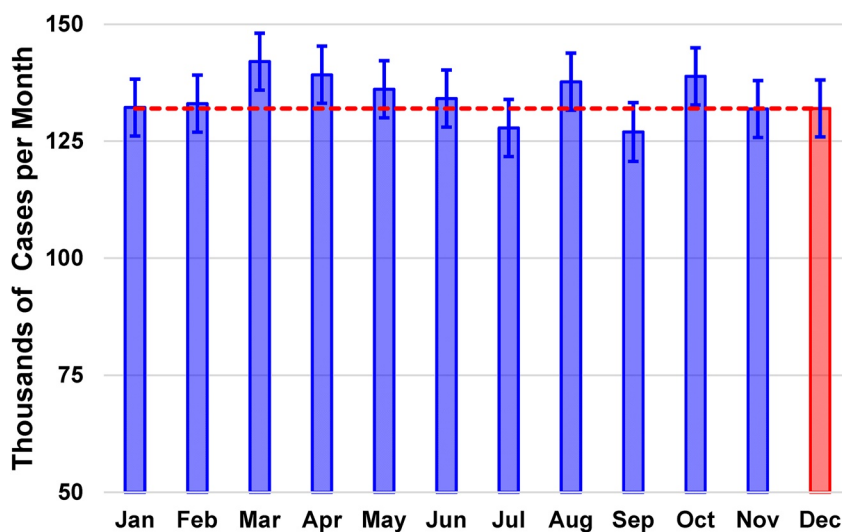
FIGURE 5 Total cases, inpatient and outpatient, among months showing that December was not reliably busier or less busy than other months. There were 119 months × year combinations analysed, the dropped one being September 2017, because of Hurricane Irma that disrupted surgical services for a week during that month. Year and month were modelled linearly as 9 and 11 categories, respectively. The resulting monthly estimates for 2019 and their 99% confidence intervals are plotted for 2019. Robust variance estimators were used. The estimate for December was greater than the estimates for 3 other months (July, September, and November [slightly]) and less than the estimates for the other 8 months [Colour figure can be viewed at wileyonlinelibrary.com]

operating rooms and hire more anaesthesia practitioners and surgical nurses to reduce the higher costs sustained by working longer hours.[25] The extent to which this model will be highly affected by the coronavirus disease 2019 pandemic is unknown.

4.1 | Limitations

Although we included Figure 6 to show calculation by workday and the positive association between workdays per month and cases, there were multiple limitations to that approach. First, we assessed workdays statewide, not for each facility. Many facilities had insufficient cases to judge workdays empirically using percentiles; only 28% (199 of the 712 with cases) had at least 100 ambulatory cases for all 20 months in the figure. Therefore, Figure 6 shows cases per workday pooled among facilities, not clustered by facility as done in Tables 1–3. Second, January has more workdays than November, reducing the ability to differentiate between the effect of different numbers of workdays in a month compared to December from the month itself. We do not think that we can reliably separate the two effects because the sample sizes are just $N = 10$ years when pooling among facilities. Third, analyses by workday seemed to supply little mechanistic insight. Figure 6 can be interpreted as showing that months with more operating room days available have more surgery. However, an equally plausible interpretation is that surgeons schedule fewer cases during months with federal holidays because the surgeons and/or their assistants are on vacation. In other words, because our excluded Mondays to Fridays were federal holidays and in some years the day before or after a federal holiday (see Section 2.2), whether the holidays were principally affecting operating room availability, surgeons' choices, or a combination was not discernible from the available data.

We examined totals statewide (Figure 1) and while clustering by facility (Tables 2 and 3), but not the corresponding behaviour within facilities. However, behavior within facilities was studied previously. At a single large hospital, workloads were compared pairwise among all surgeons × 4-week periods to understand why the assump-
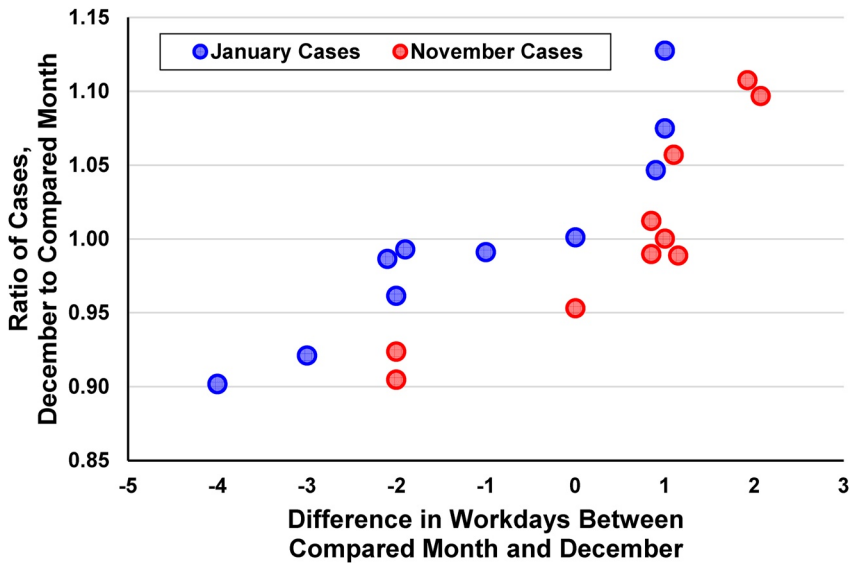
FIGURE 6 Relationship between workdays in months and caseload. The vertical axis gives the number of cases performed in December of a year divided by the number of cases performed in the comparative month of the same year, November of January. The vertical axis matches Table 2. There were N = 3,410,330 cases in those 3 months over the 10 studied years. The horizontal axis gives the number of workdays in December of a year minus the number of workdays either in the paired January or November of the year. Each of the studied years is represented by one blue dot and one red dot. December had mean (standard deviation) of 20.0 workdays (1.2), November 19.5 workdays (0.7), and January 21.1 workdays (0.9). Because some ratios overlapped, horizontal jitter was added. The figure shows positive correlation between workdays and caseloads (Spearman 0.84, $p < 0.0001$). In the Limitations we address why the relationship shown means that interpreting results per workday was not useful [Colour figure can be viewed at wileyonlinelibrary.com]

tion appeared valid to analyse surgeons separately for how they cumulatively fill allocated operating room time and why we assume stationarity for workload by groups of surgeons.[30] Over 4-week periods, the surgeons' caseloads were statistically independent.[30] Surgical workload was the cumulative sum of the workloads of many surgeons.[30] However, the generalisability of the results from that one large hospital is unknown.[30] When specialties have several surgeons working at the same facility, pairs of surgeons can be selected deliberately to operate on the same days because they together will fully fill an operating room (i.e., correlation can be produced deliberately).[31] Alternatively, when one surgeon has longer periods until operating room time is available, patients can be advised of partner(s) who can perform surgery sooner.[32] If such decision-making were made at scale, then our findings for patients with commercial insurance payers versus Medicare may have been different.

We quantified variation among months in elective surgery, not variations in late afternoon workloads including add-on cases. Late afternoon workload routinely has seasonal variation (e.g., longer work hours in the summer of a large teaching hospital).[33,34] Because the dataset used does not include the start and end times of cases, we could not explore this issue.

Years with relatively more cases and intraoperative work relative value units among patients with commercial insurance also had significantly more cases and units among patients with US Medicare insurance, and vice-versa. These findings of the absence of a causal inverse relationship applied both overall among years and when analysed by facility (Tables 2 and 3). Commercial cases were not causing fewer Medicare cases, or vice-versa. As described in the Introduction, if we had detected the opposite (i.e., significant negative association by year in the ratios), we probably would have been unable to perform causal analyses because we lack data within facilities (e.g., patient waiting times).

We considered elective surgery caseloads and intraoperative work relative value units, not an endpoint closer to anesthesia workload for surgery. For example, we could not examine total American Society of Anesthesiologists relative value guide units because they are not included in the public use data file. However, among 4-week periods, the linear (Pearson) correlation coefficients between surgeons' numbers of cases and their total American Society of Anesthesiologists' relative value guide units averaged 0.95 (95% confidence interval 0.94–0.96).[30] Pooling among surgeons, the Pearson correlation coefficient over 159 four-week periods was 0.99.[2]

Finally, and importantly, we studied surgery, not all anesthetics. After our paper was under review, Piersa and colleagues reported that among adult elective anesthetics performed by a large multistate practice, including in Florida, there were more cases in December than other months, caused by commercially insured patients.[19] Their overall percentages of cases with commercial insurance were comparable.[19] In contrast, while they found no difference in caseloads between December and other months for coronary artery bypass grafting, there were differences for colonoscopies[19]; see their Supplemental digital content Table 2. Our study included most cardiac surgery, because the procedures are major therapeutic.[14,15] Our study excluded all colonoscopy procedures because they have zero intraoperative work relative value units.[8,35] Earlier review summarised multiple reasons for lesser productivity at non-operating room anesthesia locations.[36] Comparison of our results to those of Piersa and colleagues suggests benefit to anesthesia groups adjusting their staff scheduling seasonally for non-operating room locations,[19] especially for sites with long workdays.[33,34]

4.2 | Conclusions

In the US State of Florida, December had more elective surgery among patients with commercial insurance, and less among patients with Medicare as payer.[6,7] However, the additive effect balanced, resulting in little to no extra operating room and anaesthesia workload at the end of the year, statewide. Thus, many individual surgeons doing procedures disproportionately among patients with one type of insurance (e.g., ophthalmologists doing cataract surgery) will have seasonal variation in their workload. However, surgical facilities with patients undergoing many types of procedures will have less seasonal variation. Importantly, more commercial insurance cases were not reciprocally causing Medicare cases to be postponed or vice-versa. That result provides further indication and explanation for why forecasts of surgical demand can reasonably be made (as currently assumed)[1-3] by taking the sum among many surgeons and treating their caseloads as statistically independent.

CONFLICT OF INTEREST

No conflict of interest.

ETHICS STATEMENT

Our dataset included all 57,786,140 patient encounters at all 750 non-federal ambulatory surgical facilities and hospitals in Florida between 1 January 2010, and 31 December 2019. These are data publicly available from the Agency for Health Care Administration (AHCA) supplemented by special request with the dates of each encounter (for ambulatory patients) or the date of admission (for inpatients). Provision of the specific dates was made subject to data use agreements between the University of Florida, AHCA, and the University of Miami. Facilities were deidentified before analysis. The Institutional Review Boards of the University of Miami and the University of Florida

approved this project as non-human subjects research and as exempt, respectively. AHCA disclaims responsibility for the results and conclusions of this study of seasonality.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the Florida Agency for Health Care Administration. Multiple restrictions apply to the availability of these data, which were used under license for this study. As described first paragraph of the Methods, provision of the specific dates of procedures were obtained with Institutional Review Board and Data Use Agreements among AHCA, University of Florida, and University of Miami. The data cannot be provided by the authors. Our Stata code is available on request from the authors, but that excludes the associated DTA file for execution.

ORCID

Franklin Dexter https://orcid.org/0000-0001-5897-2484

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