The Lack of Systematic Month-to-Month Variation Over One-Year Periods in Ambulatory Surgery Caseload—Application to Anesthesia Staffing

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Anesthesia groups forecast future workload so that staffing and future hiring can be adjusted. Statistical methods have been developed to estimate the number of anesthesia providers needed to minimize labor costs during regularly scheduled hours, second-shifts, and weekends. These methods are simple, in that they assume that, on this medium-range (11-mo) basis, workload varies irregularly around a mean workload. To test whether this assumption is likely to hold for many anesthesia groups nationwide, raw data from the 1994 to 1996 National Survey of Ambulatory Surgery were reanalyzed. To assure that month-to-month systematic variation in workload (e.g., seasonal variation) could be detected if it were present, the average number of myringotomy tubes inserted each day in ambulatory surgery centers of the United States was also examined. The average number of ambulatory surgery cases performed with an anesthesia provider each day in the United States per 10,000 population was found to have not varied systematically month to month on a medium-range (11-mo) basis. In contrast, the average number of tubes inserted each day varied systematically among months for all 26 of the overlapping 11-mo periods in the 36 mo of the survey. These findings suggest that the relatively simple statistical methods that are available to estimate future anesthesia workload will work for many anesthesia groups.

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A financially important task for an anesthesia group is to forecast future workload so that staffing can be adjusted. If more anesthesia providers are scheduled to work each day than are needed to complete the cases, then downtime (underutilized hours) increases, productivity decreases, and the anesthesia group's profit margins decrease (1–4). Likewise, if too few anesthesia providers are scheduled to work, cases may need to be postponed or performed later in the day resulting in overtime costs and frustrated surgeons.

Recently, methods to estimate the number of anesthesia providers needed to minimize labor costs during regularly scheduled hours, second shifts, and weekends were described (1–4). Simple analyses were sufficient. They were not much more sophisticated than calculating means (2), percentiles (1,4), and making plots (3) of several preceding months' workload. This was so because, on a medium-range (11-month) basis, mean workload did not change systematically (e.g., seasonally) month to month during regularly scheduled hours or weekends (2,4). In this context, 11 mo is being considered because this was the time period of historical data that we found previously to be optimal to predict future operating room workload (2). There was some seasonal variation in the workload during second shifts. However, it was small and would result in a difference in staffing of at most one anesthesia provider in a large surgical suite (3).

This lack of financially important systematic differences in anesthesia workload month to month differed from findings in other industries (5). For example, anesthesia groups can accurately forecast workload for the month of December by taking the mean of measured workload during the preceding 11 mo (2). In contrast, a mail order clothing retailer such as Lands' End would be foolish to forecast staffing needs for the month of December by taking the mean of measured workload during the preceding 11 mo (5). To remain competitive, companies in industries other than anesthesia (e.g., retail, amusement parks, manufacturing, and construction) have to forecast monthly workload using more complicated statistical methods that compensate for systematic month-to-month variation in workload (6–8).

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We hypothesized that the reason for the differences between our findings and those of other industries was that anesthesia workload varied little month to month not only at the sites we used to test our methods, but nationwide. To test this hypothesis, we reanalyzed raw data from the National Survey of Ambulatory Surgery. We assessed the magnitude of medium-range (11-month) monthto-month variation in the average daily number of ambulatory surgery cases performed by anesthesia providers in the United States per 10,000 population.

Methods

Review of the National Survey of Ambulatory Surgery

The United States National Center for Health Statistics used sophisticated sampling methods to complete the National Survey of Ambulatory Surgery in 1994, 1995, and 1996. The survey used probability sampling so that nationally representative results could be obtained without surveying every ambulatory surgery case in the United States (9–10).

A total of 5,252 hospitals and 1,732 freestanding ambulatory surgery facilities met the study inclusion criteria (10). Freestanding facilities included in the survey were state-licensed or certified by the Health Care Financing Administration for Medicare participation. Federal, military, and Department of Veterans Affairs hospitals were excluded. Facilities specializing in dentistry, podiatry, abortion, or childbirth were excluded.

For the survey, ambulatory surgery was defined as scheduled outpatient (admitted and discharged from the facility on the same day) surgery performed in any of the following locations: general or main operating room, satellite operating room, cystoscopy room, endoscopy room, cardiac catheterization lab, or laser procedure room (10). Patients admitted subsequently to a hospital as inpatients were included in the survey. Patients who were admitted originally as a hospital inpatient or who were admitted through the emergency room were excluded. After selection of ambulatory surgery visits for inclusion in the survey, data from each visit including the procedure(s) performed were abstracted from the medical record.

Our Analysis of the Raw Data from the National Survey of Ambulatory Surgery

Visual Basic (Microsoft, Redmond, WA) computer code was written to read the raw data of the 364,858 ambulatory surgery visits from the publicly released CD-ROM. Each of the 230,160 visits with an anesthesia provider present was considered to have been a surgical case. The characteristics of these cases were recently reported (11), and so demographics are not reported in the current study.

The National Center for Health Statistics assigned each case a weight. The weight was calculated by using statistical methods that considered the probability of selection of the case's facility, probability of selection of the case among all cases at the case's facility, and response rates of facilities and locations within facilities. The use of weights allowed the cases included in the survey to be used to determine nationally representative results.

Each case was categorized based on the month and year in which it was performed. We summed the weights of the cases performed during each of the 36 mo in the survey. The "observed" average number of ambulatory surgery cases with an anesthesia provider each day in the United States was estimated by taking the sum of these weights and dividing by the month's number of days that were not weekends or federal holidays. The result was then divided by the United States' population for the month (12).

Positive Control

The hypothesis tested was that there would not be systematic month-to-month variation in the average daily number of ambulatory surgery cases performed by anesthesia providers in the United States on a medium-range (11-mo) basis. A "positive control" was therefore devised to assure that, by using data from the National Survey of Ambulatory Surgery, systematic month-to-month variation in caseload could be detected if it were present. Monthly observations of a second endpoint were used: the average number of myringotomy tubes (International Classification of Diseases, Ninth Revision, Clinical Modification code 20.01) inserted each day in ambulatory surgery centers of the United States, expressed on a per 100,000 population basis. Myringotomy tubes insertion was selected for two reasons. First, it was the second most commonly performed ambulatory surgery procedure, with an anesthesia provider present, in the United States (11). Consequently, the monthly number of cases was sufficiently large for month-to-month variation in mean daily caseload to be detected relative to the National Survey of Ambulatory Surgery's sampling error. Second, previous epidemiological studies showed that the incidence of secretory otitis media varies seasonally (13).

Statistical Analysis

The two endpoints were examined qualitatively by using graphical methods and coefficients of variation. The standard errors were calculated for the two endpoints for each of the 3 yr in the study by using the

methods described by the National Center for Health Statistics (10).

The mean squared successive differences test (14,15) was used to test statistically whether there was a correlation between successive monthly observations of each endpoint over 11-mo periods. If this ratio of the mean of the $n = 11$ squared differences between successive observations was large relative to the sample variance of the $n = 11$ observations, then the observations would not be randomly distributed about the mean. In that 36 mo of data were available, for each of the two endpoints, the mean squared successive differences test was performed 26 times, where $26 = 36 - 11 + 1$. $P \leq 0.01$ was used as evidence of statistical significance (15) rather than the more usual $P \leq 0.05$, because there were many (i.e., 156) different P values calculated for this study, where $156 = 6$ analyses $\times$ 26 series.

The mean squared successive differences test has a high statistical power to detect correlation between successive differences, in part because the test assumes that the observations are normally distributed (14,15). For both endpoints, none of the 26 series of 11 observations was significantly nonnormal, as assessed by Lilliefors test (16).

The National Center for Health Statistics calculated the cases' weights based, in part, on the response rate of facilities. For example, if a facility participated for fewer than 12 mo in a year, the weights assigned to each reported case from that facility were increased to account for the missing month(s) of data from that facility. To ensure that such adjustments for the partial nonresponse of facilities did not affect our results, we repeated our statistical analyses using weights calculated only from facilities that participated during all 12 mo of each year. So that we could perform this analysis, National Center for Health Statistics' statisticians provided us with special summary data from the fully responding facilities; this information was not available in the publicly released data files.

Results

Figure 1 shows month-to-month variation in the average number of ambulatory surgery cases with an anesthesia provider each day in the United States per 10,000 population. The month-to-month systematic variation in average daily caseload was statistically significant for one of the 26 overlapping 11-mo periods. After limiting consideration to caseloads at facilities that fully responded to data requests for the survey, there was no significant variation for all of the 26 overlapping 11-mo periods.

Figure 2 displays month-to-month variation in the average number of myringotomy tubes inserted each day in ambulatory surgery centers in the United States per 100,000 population. The month-to-month systematic variation in inserted myringotomy tubes was statistically significantly for all 26 of the overlapping 11-mo periods. After limiting consideration to tubes inserted at facilities that fully responded to data requests for the survey, there was still significant variation for all of the 26 overlapping 11-mo periods.

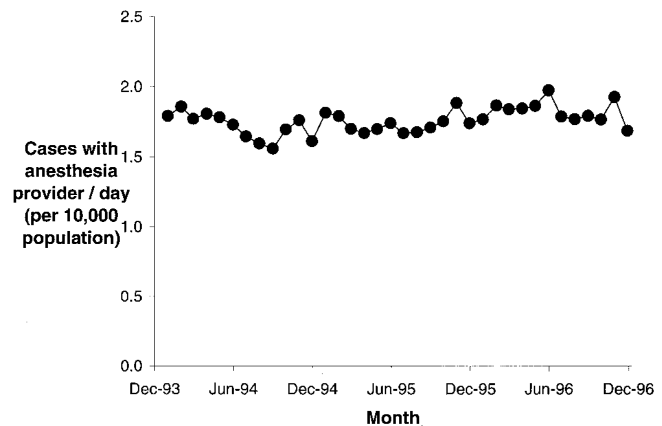

Figure 1. Month-to-month variation in the average number of ambulatory surgery cases with an anesthesia provider each day in the United States, reported per 10,000 population. The coefficient of variation among the 36 mo was 5.2%. The mean ± standard errors were 1.72 ± 0.10, 1.74 ± 0.10, and 1.82 ± 0.10 for 1994, 1995, and 1996, respectively.

Discussion

Implications for Anesthesia Groups

The current study showed that the average number of ambulatory surgery cases performed each day per 10,000 population in the United States with an anesthesia provider did not vary systematically month to month on a medium-range (11-mo) basis. These findings are important because they increase the likelihood that the previously developed statistical methods to estimate the number of anesthesia providers needed to minimize labor costs during regularly scheduled hours, second shifts, and weekends (1–4) will work for many anesthesia groups. This is of large practical importance, in that computer software written to use these relatively simple statistical methods will be adequate for most anesthesia groups. Simple software can have a large market.

These results do not mean that anesthesia workload will not vary seasonally for all anesthesia groups. For example, in a study describing second shift staffing, a figure was included showing some slight seasonal variation in afternoon workload at the University of Iowa (3). Medical groups should check for seasonality (17). We think that the results of the current study imply that anesthesia groups can reasonably perform data collection and statistical analysis based on the *a*

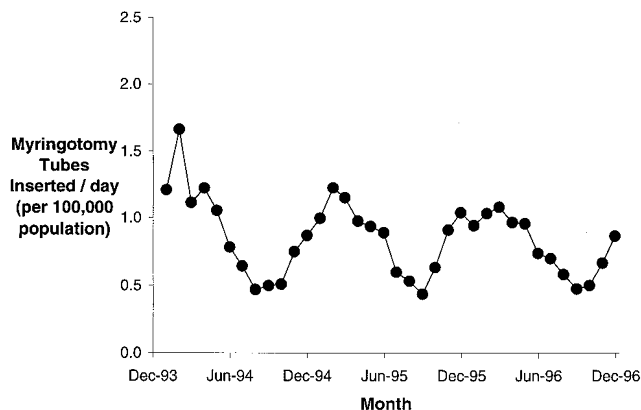

Figure 2. Month-to-month variation in the average number of myringotomy tubes inserted each day in ambulatory surgery centers of the United States, reported per 100,000 population. The coefficient of variation among the 36 mo was 32.6%. The mean ± standard errors were 0.89 ± 0.06, 0.86 ± 0.06, and 0.79 ± 0.05 for 1994, 1995, and 1996, respectively. The incidence of secretory otitis media peaks toward the end of winter and is lowest toward the end of summer (13). As shown in the Figure, the number of myringotomy tubes inserted peaks in February to March and is lowest in August to September.

priori assumption that there will not be systematic medium-range variation in workload. Then, after performing the analysis, the anesthesia group can use inferential (2,4) and graphical (3) methods to confirm that this assumption has not been violated significantly. This approach requires many fewer years of data and much simpler statistical methods than starting the analysis with the expectation that there will be seasonal variation.

The strategy of starting with several months of data and using a simple analysis differs markedly from reasonable approaches for other industries. For example, whereas we found the coefficient of variation in anesthesia caseload among months to be 5.2% (Figure 1), staffing at the mail order clothing retailer Lands' End is increased by more than 45% in November and December (5). Likewise, an accounting group probably should not start with the assumption that workload for the month before the April tax-filing deadline will equal the mean of the workload during the proceeding several months. Instead, the corresponding "simple" approach would be to take the mean over several proceeding years of the workload during the month before the tax-filing deadline. Over a several-year (versus -month) period, the opportunities for trends to affect workload are marked, so that forecasting workload simply by taking the mean of historical workload may be highly inaccurate.

The absence of systematic month-to-month variation in anesthesia caseload would be expected to result in an absence of systematic month-to-month variation in net income, accounts receivable, and gross profit margin (18). Consequently, monitoring the business and accounting practices of an anesthesia group can be easier than in other industries (18).

With a lack of systematic month-to-month variation in anesthesia workload, anesthesia groups only need approximately one year of historical data to determine whether an apparent increase or decrease in workload during a month or two represents a statistically significant trend (2). Upper prediction bounds for future workload can be calculated to assure that planned staffing during future months will be sufficient to handle the workload with minimal overtime costs or excessively long hours (2).

Explanation for Our Findings

Whereas some surgical procedures are performed more during the winter than the summer (Figure 2), other procedures may be performed more during the summer than winter. Anesthesia providers care for patients undergoing more than 10,000 different procedures (11). Because there are so many different procedures, seasonal variations in the incidences of individual procedures may average out to produce a relatively constant monthly workload. If this explanation were true, then anesthesia groups that care for patients undergoing only one type of procedure (e.g., a facility dedicated solely to pediatric otolaryngology) may need to forecast seasonal variation in caseload.

The daily number of cases was analyzed per 10,000 population. Anesthesia caseload can change markedly over a short time period because of changes in the "effective" population. For example, if an anesthesia group suddenly gets an insurance contract to provide anesthesia care for an additional 200,000 covered lives, anesthesia workload will change quickly. The statistical methods (1–4) are appropriate when the population size is relatively stable from month to month.

Limitations

The analysis considered only ambulatory surgery, not inpatient surgery. Based on our clinical experience, we expect that we would have obtained similar results for inpatient surgeries. However, we do not have national data to support this hypothesis. Results from the National Hospital Discharge Survey were not included in this study for two reasons. First, its method of probability sampling made analysis on a monthly basis unreliable (19). Second, its sampling methodology targeted all hospital discharges, including patients who did not undergo surgery. In 1996, the number of ambulatory and inpatient procedures per 1,000 population was 119.3 ± 5.0 and 153.0 ± 6.2, respectively (20). Therefore, ambulatory surgery represents an important percentage of surgical procedures performed in the United States.

The publicly released data from the National Survey of Ambulatory Surgery contains data on the monthly

number of cases with an anesthesia provider, not monthly hours of cases (i.e., workload). The difference between caseload and workload would affect our results if mean case duration among all cases nationwide were to vary systematically month to month. Although we have no reason to think that the mean case duration would vary among months (nationwide), we know of no publicly released data to test this hypothesis. At the University of Iowa, among the 36 months between July 1994 and June 1997, the coefficient of variation among months in the monthly average case duration was only 4.4%.

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