

Quantifying Net Staffing Costs Due to Longer-than-average Surgical Case Durations

Amr E. Abouleish, M.D., M.B.A.,* Franklin Dexter, M.D., Ph.D.,† Charles W. Whitten, M.D.,‡ Jeffery R. Zavaleta, M.D.,§ Donald S. Prough, M.D.||

Background: Anesthesiology departments incur staffing costs that are not covered by revenue because the operating room (OR) time allocation and case scheduling are not done to maximize OR efficiency and because surgical durations are longer than average. The purpose of this article is to demonstrate a method to quantify net anesthesia staffing costs due to longer-than-average surgical durations and evaluate the factors that influence staffing costs.

Methods: Data collected from two anesthesiology departments in academic hospitals for 1 yr included date of surgery, time that patients entered the OR, time that patients exited the OR, surgical service, and the Current Procedural Terminology code for the primary surgical procedure. Anesthesia care performed outside the main surgical suite and services not billed with American Society of Anesthesiologists units were excluded. National average surgical durations were determined from the Current Procedural Terminology code from the Centers for Medicare and Medicaid Services' database. Actual surgical durations were then used to determine staffing solutions to maximize OR efficiency; national average surgical durations were then used to determine a second solution. The difference in staffing costs between these two staffing solutions represented the staffing costs attributable to longer surgical durations. Costs were converted to dollar amounts using compensation values reported in a national compensation survey. The differences in revenue were determined by applying conversion factors to the differences in surgical durations. The annual net cost attributable to longer surgical durations equaled the staffing costs minus the revenue produced by longer durations. Net staffing costs were estimated for two hospitals using median staffing compensation and median payer mix. Net staffing costs were then recalculated by varying the parameters (conversion factors, limits on differences between actual and average surgical duration, levels of compensation, surgical service size of OR allocation).

Results: Using the median compensation of staff and an average conversion factor, the net annual staffing costs attributable to longer surgical durations were \$672,100 for the first hospital. However, if staff members were highly compensated and the payer mix was unfavorable, the net staffing costs were \$1,688,000. Reducing the difference between actual and average duration resulted in lower staffing costs. Net staffing costs were less in a second hospital studied that had many low-volume surgical services.

Conclusions: Longer-than-average surgical durations can increase net staffing costs for anesthesiology groups. The increase is dependent on factors such as staffing compensation and payer mix.

ACTUAL clinical workload (e.g., total American Society of Anesthesiologists [ASA] units billed per operating room [OR], cases per OR) does not directly determine staffing requirements for anesthesiology departments because anesthesia staffing requirements for a surgical suite depend on the number of staffed anesthetizing sites (OR sites), the staffing ratio (concurrency), and the number of evening shift, on-call, and postcall providers.¹ Although clinical workload should ideally determine the number of OR sites to be staffed and therefore should indirectly determine the staffing requirements, OR allocation by hospital administrators or OR committees may be based on goals other than maximizing OR efficiency (e.g., surgeons' preference of first starts, timing of elective add-on cases, or organizational resistance to change), which leads to increased staffing costs for the anesthesiology department.²⁻⁷ If clinical workload and staffing requirements are sufficiently misaligned, staffing costs may exceed revenue and necessitate subsidization by hospital administrations or medical schools.^{2,8,9}

In academic medical centers, inefficient utilization of anesthesia personnel may be exacerbated by longer-than-average surgical case durations that are typical of these institutions because of the training of surgical and anesthesiology residents that occurs. Longer durations decrease the anesthesiology departments' hourly clinical productivity (defined as total ASA units per hour of clinical care).¹⁰⁻¹² To provide the same amount of clinical work (defined as total ASA units produced per OR), anesthesia personnel within academic anesthesiology departments must work more hours of clinical care than personnel in departments that provide care in cases with average or shorter-than-average durations.

Both the staffing costs from OR allocation and case scheduling not being based on OR efficiency and from longer-than-average surgical duration are costs that anes-

* Associate Professor, || Rebecca Terry White Professor and Chair, Department of Anesthesiology, The University of Texas Medical Branch. † Associate Professor, Department of Anesthesia, The University of Iowa. ‡ M. T. "Pepper" Jenkins Professor in Anesthesiology, § Resident, Department of Anesthesiology and Pain Management, The University of Texas Southwestern Medical Center at Dallas.

Received from the Department of Anesthesiology, The University of Texas Medical Branch, Galveston, Texas; the Division of Management Consulting, Department of Anesthesia, The University of Iowa, Iowa City, Iowa; and the Department of Anesthesiology and Pain Management, The University of Texas Southwestern Medical Center at Dallas, Dallas, Texas. Submitted for publication March 7, 2003. Accepted for publication September 30, 2003. Supported in part by a Research Education Grant (to Dr. Abouleish) from the Foundation for Anesthesia Education and Research, Rochester, Minnesota, and by departmental funds, Department of Anesthesiology, The University of Texas Medical Branch, Galveston, Texas. Medical Data Applications, Ltd., Jenkintown, Pennsylvania, developed and distributes CalculatOR software, which performed the analysis described in this article. Medical Data Applications, Ltd. provided funding to the Division of Management Consulting, Department of Anesthesia, The University of Iowa, Iowa City, Iowa. Steven L. Shafer, M.D., served as acting Editor-in-Chief for this article.

Address reprint requests to Dr. Abouleish: Department of Anesthesiology, University of Texas Medical Branch, 301 University Boulevard, Galveston, Texas 77555-0591. Address electronic mail to: aaboule@utmb.edu. Individual article reprints may be purchased through the Journal Web site, www.anesthesiology.org.

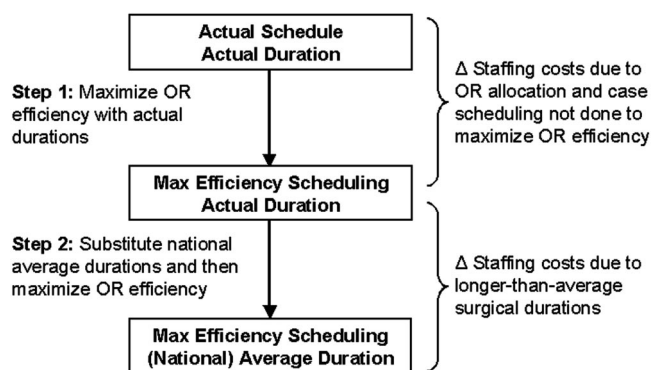


Fig. 1. Overview of the methodology. Net staffing costs for anesthesiology departments can arise from two variables: (1) operating room (OR) allocation and case scheduling not done to maximize OR efficiency, and (2) longer-than-average surgical durations. To evaluate the second variable, step 1 is to optimize the OR allocation and case scheduling using actual surgical durations resulting in the Max Efficiency Schedule–Actual Duration solution. Step 2 is to optimize after substituting national averages for surgical durations resulting in the Max Efficiency Schedule–National Average Duration solution. The increased staffing costs due to longer-than-average durations are calculated by comparing staffing costs between Max Efficiency Schedule–Actual Duration and Max Efficiency Schedule–National Average Duration. The net costs are the costs minus the expected revenue for increased hours of care.

thesthesiology departments cannot directly control. Subsidization of staffing costs of academic anesthesiology departments can be justified by quantifying the excess costs of additional staffing. In a previous study, we described the methodology for quantifying the costs associated with not allocating OR time and scheduling cases to maximize OR efficiency.² In this study, we examined a method of quantifying the net staffing costs associated with longer-than-average surgeries and the factors determining the net staffing costs.

Materials and Methods

Overview of Analysis

The steps for the analysis are illustrated in figure 1. Two variables contribute to excess staffing costs. The first is increased staffing costs because OR allocation and case scheduling are not done to maximize OR efficiency.^{2–4,6,7} The second is the increased staffing costs attributable to longer-than-average surgical durations. To evaluate the second variable, the first must be quantified. Therefore, the first step is to determine the best staffing solution that would be possible if OR allocation and case scheduling were done to maximize OR efficiency. That first step is accomplished using actual, historic case durations to generate a staffing solution that is termed *Max Efficiency Schedule–Actual Duration*. In the second step, we substitute national average surgical durations for actual historic durations and determine OR allocation and case scheduling to maximize OR efficiency to develop a staffing solution termed *Max Effi-*

ciency Schedule–National Average Duration. The difference in staffing costs between the Max Efficiency Schedule–Actual Duration solution and the Max Efficiency Schedule–National Average Duration solution is attributable to longer-than-average surgical durations. However, the time units that are billed for additional time generate additional revenue that partially offsets increases in staffing costs. The increased costs that are not covered by the increase in revenue are the net staffing costs of longer-than-average surgical durations.

Surgical Case and OR Data

After institutional review board approval at two academic medical centers (hospital A and hospital B), data were collected retrospectively for one calendar year (1999 for hospital A, 2000 for hospital B). All surgical cases for which anesthesia was provided within the main surgical suite of each hospital on a regularly scheduled workday were included. Cases performed on weekends and holidays were excluded. Anesthesia services for surgical cases performed outside the main surgical suite (e.g., in the labor and delivery, radiology, cardiology, or endoscopy suite) were excluded. Data collected from the anesthesia billing database were the primary surgical Current Procedural Terminology (CPT) code for which the anesthesiology CPT code was billed, number of anesthesia minutes billed, and patient identifiers (e.g., medical record number, date of surgery, OR number, and age). Data collected from the OR information system included the in-room time (time when patient entered the OR) and date, out-room time (time when patient left the OR) and date, surgical service performing the surgery, OR number, and patient identifiers. The data from the two databases were merged into one database based on the patient identifiers. After the merger, the patient identifiers were removed (replaced by a coded number with the key kept in a secure location at each of the hospitals). Surgical duration for each surgery was defined as the time the patient was in the OR (i.e., out-time minus in-time).

Surgical services were identified by their OR allocation. That is, if OR administration allocated OR time to a specific service, that service was identified, regardless of whether the “service” was an individual surgeon, a small group, or a department. If, independent of OR administration, a service further divided allocated OR time internally, only the larger service was included. For example, in hospital A, OR administration allocated four ORs each day to orthopedic surgery, but internally, orthopedic surgery allocated these rooms to different subspecialty services (e.g., pediatric, ankle/foot, spine/back, and general). For purposes of this analysis, only the orthopedic surgery service was identified at hospital A. At hospital B, OR administration specifically allocated OR time to each subspecialty; therefore, for purposes of

this analysis, each of the subspecialty services was individually identified at hospital B.

For each hospital, regular hours were defined as the scheduled resource hours.¹³ The regular hours included the sum of all the allocated OR time and were usually determined by the day and repeated weekly. Overutilized hours included evening and night hours in which surgery was performed after the end of regular hours during weekdays.

National Average Surgical Duration

For each surgery, the primary CPT was identified. For each CPT, the Center for Medicare and Medicaid Services has assigned time for preprocedure, intraprocedure, and postprocedure as part of the process of determining the work relative-value units for the CPT code.[#] For this study, the intraprocedure time was considered the surgical duration.

When substituting average surgical durations for actual surgical durations, we controlled the influence of extreme outlier durations by imposing two limits, 60 min and 180 min, on differences in times. Separate calculations were then performed with each of the limits. If the difference between the average and the actual time of a procedure exceeded that limit, the actual time was only reduced by the limit. For example, if the actual duration of a case was 480 min, and the national average was 85 min, but the limit was 180 min, the substituted duration used in the study was 300 min (480 min minus 180 min), not 85 min.

Determining Staffing Solution to Maximize OR Efficiency

An *underutilized hour* of OR time is a regularly scheduled hour in which no surgery is performed and no turnover of the OR is occurring. An *overutilized hour* of OR time is an hour during which surgery occurs after regular hours. The OR time has been allocated to maximize OR efficiency when the allocated hours minimizes the weighted sum of expected underutilized and overutilized hours. Mathematically, the weighted sum equals the number of underutilized hours plus 1.75 times the number of overutilized hours. The weighting of overutilized hours recognizes that the cost of an overutilized hour exceeds that of a regular hour because of increased direct costs (*i.e.*, personnel usually must be compensated at a higher rate for undesirable hours) and indirect costs (*i.e.*, costs to the group for recruitment of new members due to turnover of personnel because of excessive numbers of undesirable hours). For example, if an anesthesiologist were scheduled to work 10 h from 7 AM to 5 PM and instead worked until 7 PM, the labor cost

would be equal to the cost of 13.5 regular hours, where $13.5 = (10 \text{ regular hours}) + 1.75 \times (2 \text{ overutilized hours})$.

For each hospital, the OR allocation and case scheduling that maximized OR efficiency was performed on the data as previously described.²⁻⁴ Briefly, OR allocations were calculated independently for each surgical service using a statistical software package (CalcuTOR; Medical Data Applications, Ltd., Jenkintown, PA) that maximizes the expected efficiency of use of the OR staff.^{3,5,6,14,15} The smallest-cost, first-shift staffing solution, *i.e.*, the smallest weighted sum of underutilized and overutilized hours, was determined by considering all possible combinations of staffed regular hours and the accompanying numbers of underutilized and overutilized hours. For hospital A, possible allocated regular hours per service began at 0 h and progressed incrementally to 8 h, 10 h, 16 h, and so forth (those being the options in current use at hospital A). For hospital B, the possible regular hours were 0 h, 8 h, 10 h, 13 h, 16 h, and so forth. Starting with 0 h, progressively larger numbers of staffed hours were considered until additional increases in the staffed hours caused the weighted sum of underutilized and overutilized hours to increase. If providing 0 h to a service resulted in a lower cost than providing the minimum of 1 OR for 8 h, no OR was assigned to that surgical group for that day, and it was combined with all other such groups into another service, termed *OTHER*. The solution for the *OTHER* service was then calculated. At least 1 OR was allocated for *OTHER* services for at least 8 h each day of the week. This rule meant that every service had open access to open OR time every workday. There was also an inherent assumption that the cases were scheduled based on maximizing OR efficiency.⁴

Determining Hourly Staffing Costs

In evaluating the costs attributable to longer-than-average surgical durations, the study focused on the marginal hours that would be reduced if surgical durations were reduced. In the academic groups studied, this hourly cost is different than the average hourly staffing cost because of differences in the likely mix of providers during marginal hours.¹⁶ Average hourly staffing costs include the costs of all providers: faculty, nurse anesthetists (CRNAs), anesthesia assistants, and residents. In contrast, we assumed that marginal staffing costs would only include the cost of faculty and CRNAs or anesthesia assistants because we assumed that academic programs would preferentially reduce staff costs by reducing providers that have higher hourly costs than residents. Further, we assumed that staffing of marginal rooms by faculty anesthesiologists and CRNAs would be based on a ratio of 1 anesthesiologist to every 2 ORs. Although the concurrency for academic programs is less than 1:2 (faculty:OR sites), presumably because faculty anesthesiologists supervise only one resident on intensive cases

[#] Centers for Medicare and Medicaid Services: Physician time associated with work RVUs used in creating 1999 practice expense relative values. Available at: <http://cms.hhs.gov/physicians/pfs/resource.asp>. Accessed May 29, 2003.

(e.g., neonatal surgery), we assumed that faculty would supervise two rooms of CRNAs during marginal hours. Although an anesthesiologist theoretically could supervise more than two rooms of CRNAs, we assumed that few academic medical centers would utilize that option. Therefore, for each OR hour, the hourly staffing costs were the sum of hourly CRNA costs and half of the faculty hourly costs.

The yearly compensation was calculated using nationally published survey data.^{17,18} The average total compensation per anesthesiologist was the weighted average of the different compensations for each of three categories of ranks. In addition to associate professors, we grouped instructors and assistant professors in one category, *assistant professor*, and professors and chair in one category, *professor*. Using the national survey,¹⁹ the distribution by rank was 27% professor, 25% associate professor, and 48% assistant professor.

The staffing costs to the department include total compensation plus benefits (e.g., social security tax employer contribution, medical and dental insurance, and administrative support). For the study, the cost of benefits was 26% of total compensation.

The hourly cost was determined by dividing the annual cost to the department by the estimated number of clinical hours worked by faculty anesthesiologists and CRNAs, assuming 50 weeks of 40 h each for CRNAs and 45 h each for anesthesiologists. The use of 50 weeks assumes that a department must provide coverage for 247–250 regularly scheduled OR days per year. The 40 h for CRNAs was used because at both hospitals studied, a CRNA works 40 h a week with no call. In contrast, an anesthesiologist is estimated to work *clinically* 45 h a week. The 45 h comes from the following estimate: 4.5 ten-hour days a week (clinical FTE 0.90), which is 45 h, or 4 ten-hour days a week (clinical FTE 0.80) and three calls a month (with postcall day off).

The hourly staffing costs were calculated for the 25th, 50th (median), 75th, and 90th percentiles of compensation reported for faculty and CRNAs.¹⁸

Determining Hourly Revenue

Anesthesia care is billed and paid for using both base units (determined by the type of surgery performed) and time units (determined by the case duration). In the comparisons between Max Efficiency Schedule–Actual Duration and Max Efficiency Schedule–National Average Duration, the numbers and types of surgical procedures are identical, but the durations of the cases are different. Because differences between the two staffing solutions relate only to differences in time billed, the hourly revenue used in the study is not total revenue per hour of care (which includes base units), but specifically the hourly revenue without base units. Using 15-min time units, the hourly revenue equals 4 times the conversion factor.

The conversion factor for a group is the weighted average of the different payers' conversion factors. We estimated hourly revenue for three different ranges of payer mixes: unfavorable, median, and favorable. The median payer mix conversion factor, \$26.60/unit, was the median of academic groups surveyed in 2000.⁹ The unfavorable payer mix factor was \$17.50/unit, and the favorable payer mix factor was \$31.25/unit. The unfavorable payer mix was estimated to have a payer mix of 35% Medicaid, 32% Medicare, 15% commercial/managed care, and 18% indigent. The favorable payer mix was estimated to have a payer mix of 15% Medicaid, 25% Medicare, 55% commercial/managed care, and 5% indigent. The conversion factors used for the estimates were \$15.00/unit Medicaid,²⁰ \$17.00/unit Medicare,²¹ \$45.00/unit commercial/managed care,²² and \$0.00/unit for indigent.

Determining Net Staffing Costs Due to Longer-than-average Surgical Duration

Gross staffing costs associated with longer-than-average surgical durations can be estimated directly. Subtraction of the revenue (from additional time units) associated with longer surgical duration yields net staffing costs (= increased gross staffing costs minus increased revenue). The difference in staffing costs and revenue were calculated by the following formulas:

$$\Delta \text{Staffing Costs} = \text{Hourly Cost}$$

$$\times [\Delta \text{Regular h} + (1.75 \times \Delta \text{Overutilized h})]$$

$$\Delta \text{Revenue} = \text{Hourly Revenue} \times (\Delta \text{Case Durations})$$

where Δ Regular h, Δ Overutilized h, and Δ Case Durations are the differences in hours between Max Efficiency Schedule–Actual Duration and Max Efficiency Schedule–National Average Duration. Underutilized hours are not shown in the formulas because once an OR is staffed for regular hours, the staffing costs are fixed, regardless of whether cases are performed.

Scenarios Using Different Parameters

Net staffing costs were calculated for hospital A using median staffing compensation, median payer mix (i.e., conversion factor), and a 180-min limit to difference between actual and average durations (scenario 1).

To demonstrate how the parameters influenced the quantification of net staffing costs, the net staffing costs were estimated for several different scenarios by varying parameters:

- Scenario 2: Influence of high staffing compensation and unfavorable payer mix. Staffing compensation is high due to increased demand and low supply of anesthesia providers (faculty physicians and CRNAs) and poor payer mix (e.g., county/indigent hospital). For this scenario, we used the 90th percentile for staffing

compensation, an unfavorable payer mix, and the 180-min limit for hospital A data.

- Scenario 3: Influence of low staffing compensation and favorable payer mix. Staffing compensation can be low for providers if greater numbers of providers prefer to work in that facility or market (city/state) and the payer mix is favorable (e.g., academic medical center that is not the primary county facility). For this scenario, we used the 25th percentile for staffing compensation, a favorable payer mix, and the 180-min limit for hospital A data.
- Scenario 4: Influence of difference in actual and average durations. In this scenario, we determined the effect of local surgical durations that exceeded the national averages by a smaller increment than the actual local durations. We accomplished this by calculating net staffing costs using a 60-min limit (in contrast to a 180-min limit) on the difference between actual and average surgical durations. Hospital A data, median staffing compensation, and median payer mix were used.
- Scenario 5: Influence of number and workload of surgical services. This scenario applies the methods to a setting that resembles private practice in that many low workload surgical services use OR time in contrast to the smaller number of high workload services that typically are found in academic centers. In the private practice setting, the services (i.e., the units of OR allocation) are typically by individual surgeons or small groups. For this analysis, we used hospital B data because hospital B has a higher number of services with lower workloads than hospital A. The staffing solution included more overutilized hours for hospital A than hospital B. Net staffing costs were then estimated using hospital B data and median staffing compensation, median payer mix, and a 180-min limit.

Results

At hospital A, 13 surgical services performed 12,769 cases in 24 ORs in 1 yr (table 1). At hospital B, 25 surgical services performed 12,803 cases in 18 ORs in 1 yr. Hospital B, in contrast to hospital A, allocates OR time to subspecialty services at the OR level. For example, the OR administration of hospital A allocates time to the large gynecology department (considered in this analysis to be a service), which in turn allocates OR time to each of the department's specialty groups, (e.g., gynecology, oncology). For our analysis, the individual groups, which do not receive those assignments at the OR level, are not considered services. In contrast, the OR administration of hospital B allocates time to give separate smaller services (gynecology A, gynecology B, gynecology C, gynecology-oncology, gynecology-urology). Differences in the number of services are important because

Table 1. Hospital and Surgical Case Characteristics

	Hospital A	Hospital B
No. of ORs	24	18
No. of cases	12,769	12,803
No. of surgical services	13	25
Actual surgical duration (mean \pm SD), h	2.8 \pm 2.0	2.5 \pm 1.8
National average surgical duration (mean \pm SD), h	1.5 \pm 1.2	1.5 \pm 1.0
Anesthesia time billed per case (mean \pm SD), h	2.9 \pm 2.1	2.6 \pm 1.9
Surgical duration/anesthesia time, %	91	90

Characteristics for 1 yr of surgeries performed at two different academic medical centers in the United States. *Surgical duration* is defined as the time the patient is in the operating room (OR). National average times are from Centers for Medicare and Medicaid database. For each hospital, the national average duration represents the same surgeries performed but with average duration substituted. Because each hospital performed a different mix of surgeries, the national average surgical duration is not the same for both hospitals because this average is the average of all the surgeries but using the national average duration for each surgery.

that variable influences the calculated OR allocation to maximize OR efficiency.

Actual case durations for both hospitals differed substantially from national average case durations, with mean actual values for hospital A and hospital B of 2.8 ± 2.0 and 2.5 ± 1.8 h, respectively, and mean national average values of 1.5 ± 1.2 and 1.5 ± 1.0 h, respectively (table 1). The national average times differ between the two hospitals because the numbers and types of procedures differ. The distribution of case durations differed between the actual and the national average (fig. 2). Although more than 50% of the cases had actual durations exceeding 2 h, only 25% of national average durations for the same procedures exceeded 2 h. Similarly, at hospitals A and B, 32% and 24% of cases, respectively, exceeded a duration of 3 h, whereas only 8% and 6%,

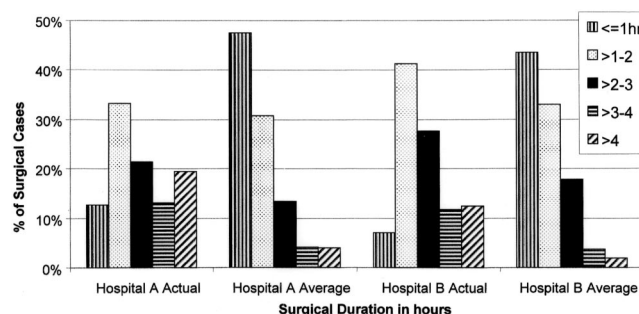


Fig. 2. Distribution of surgical cases by surgical duration. The average duration is the national average and is determined by the primary surgical Current Procedural Terminology code for the case at each hospital. For both hospital A and hospital B, more than 50% of the cases had surgical durations of 2 h or more, whereas for the same Current Procedural Terminology codes, less than 25% of the cases had average durations exceeding 2 h. Similarly, at hospital A, 32% of the cases exceeded 3 h, and at hospital B, 24% of the cases exceeded 3 h, whereas national averages for the same surgical procedures were 8% and 6%, respectively.

Table 2. Compensation for Anesthesia Providers (2001 Data)

	Percentiles			
	25th	50th	75th	90th
Faculty anesthesiologist				
Total compensation	\$187,600	\$209,300	\$239,900	\$273,400
Total with benefits	\$236,300	\$263,700	\$302,200	\$344,400
Hourly cost	\$118	\$132	\$152	\$172
CRNA				
Total compensation	\$81,700	\$89,200	\$103,900	\$142,400
Total with benefits	\$103,000	\$112,400	\$131,000	\$179,400
Hourly cost	\$51	\$56	\$65	\$90
Total hourly cost*	\$111	\$122	\$141	\$176

Compensation data from the Medical Group Management Association 2002 Survey based on 2001 data. Faculty compensation values are weighted averages of all ranks. Hourly compensation is based on 50 weeks/yr, with 45 h/week for faculty and 40 h/week for certified registered nurse anesthetists (CRNAs). Because of the medical direction ratio of 1:2, the total hourly cost equals the CRNA hourly cost plus half of the faculty hourly cost. The total hourly cost is used as the cost to staff a regular hour. The cost of an overutilized hour was considered to equal 1.75 of the regular hour.

* Total hourly cost = 0.5 faculty + 1.0 CRNA.

respectively, of national average durations for the same procedures exceeded 3 h.

Hourly Staffing Costs

The total compensation (without benefits) for individual faculty members based on the distribution of the ranks ranged from \$187,600 (25th percentile) to \$273,400 (90th percentile), with a median of \$209,300 (table 2). The total compensation (without benefits) for individual CRNAs ranged from \$81,700 (25th percentile) to \$142,400 (90th percentile), with a median of \$89,200. Total costs to the departments were calculated as total compensation plus 26% benefits. Therefore, hourly staffing costs per OR ranged from \$111 (25th percentile) to \$176 (90th percentile), with a median of \$122 (table 2).

Hourly Revenue

Using 15-min time units, the hourly revenue for additional hours of care would be 4 times the applicable conversion factor. Therefore, hourly revenue was \$70/h for an unfavorable payer mix, \$106/h for a median payer mix, and \$125/h for a favorable payer mix (table 3).

Net Staffing Costs Due to Longer-than-average Surgical Durations

The net staffing costs were quantified for hospital A and hospital B using different parameters as described in

the scenarios (table 4). For hospital A, using median staffing compensation, median payer mix, and a 180-min limit on the difference between the local duration of a case and the national average duration (scenario 1), the net annual anesthesiology staffing cost due to longer surgical durations was \$672,100. If the staffing costs were higher while the revenue was less (scenario 2), the net costs were higher (\$1,688,000) than in scenario 1. In contrast, if the staffing costs were lower while revenue was higher (scenario 3), the revenue exceeded the staffing costs, resulting in a negative net staffing cost (−\$37,200), *i.e.*, a net profit. If the difference between actual and national average durations was reduced by using a 60-min limit on the difference between the local duration of a case and the national average duration (scenario 4), the net costs were reduced (\$319,700) as compared with scenario 1. For scenario 5, hospital B data were used. Hospital B had a higher number of surgical services for a similar number of cases and durations as hospital A. Therefore, the OR workload per service for hospital B was less, and the staffing solution had fewer overutilized hours when actual data were used (Max Efficiency-Actual) as compared with hospital A (scenario 1). When the average duration was then substituted for actual durations (step 2 of the analysis), there were fewer overutilized hours that could potentially be reduced. Therefore, the net staffing costs esti-

Table 3. Payer Mix and Average Conversion Factor

Payer Mix	Average CF (\$/ASA Unit)	Percentage of Payer*			
		Medicaid (\$15.00)	Medicare (\$17.00)	Commercial/Managed Care (\$45.00)	Indigent/Self-pay (\$0.00)
Favorable	\$31.25	15	25	55	5
Average	\$26.60	25	32	38	5
Unfavorable	\$17.50	35	32	15	5

Revenues for longer surgical durations were determined by the payer mix as shown. The average payer mix was adapted from Tremper *et al.*⁹ Conversion factors (CFs) for payers were from published references (see text).

* CF = \$/ASA unit.

ASA = American Society of Anesthesiologists.

Table 4. Net Anesthesiology Staffing Costs for Different Scenarios

Scenario	Hospital	Limit on Difference between Actual and Average Durations	Staffing Compensation, Percentile	Payer Mix	Net Staffing Costs for 1 yr
1	A	180 min	50th	Median	\$672,100
2	A	180 min	90th	Unfavorable	\$1,688,000
3	A	180 min	25th	Favorable	(\$37,200)
4	A	60 min	50th	Median	\$319,700
5	B	180 min	50th	Median	\$345,000

Longer-than-average surgical durations result in longer staffed hours (increased staffing costs) and increased revenue. Staffing costs minus revenue equals net staffing costs. Several scenarios using different parameters are shown with the resultant net staffing costs. Details in scenario and parameters are described in the text. For comparison, the scenarios can be viewed as the following: scenario 1 = example academic medical center; scenario 2 = high staffing costs with low revenue; scenario 3 = low staffing costs with high revenue; scenario 4 = surgical duration not much longer than average; scenario 5 = hospital with operating room allocation to many low-volume surgical services.

mated in scenario 5 were less (\$345,000) than those of scenario 1.

Discussion

Both academic and private practice anesthesiology departments are challenged in recruiting and retaining anesthesiologists to meet clinical obligations.^{23,24} In economic terms, the shortage of the supply (relative to the demand) leads to an increase in compensation costs for anesthesiology groups. Without increasing conversion factors or increasing the workload of each OR, revenue increases will not offset the increase in staffing costs. Therefore, within a competitive market, recruitment and retention of sufficient numbers of anesthesiologists and CRNAs to staff the desired number of OR sites frequently necessitates that hospitals, medical schools, or practice plans supplement anesthesiology groups' revenue to meet the staffing costs.^{8,9,23,25} Without supplementation, anesthesiology groups are not able to recruit and retain providers to cover the clinical sites desired by the hospital.

One approach to reducing the disparity between staffing costs and revenue is to improve OR allocation and case scheduling with the goal of maximizing OR efficiency and thereby reducing the costs of anesthesiology staffing. Unfortunately, this is often not the major goal of OR allocation and case scheduling, and therefore, increased staffing costs are incurred by the anesthesiology department without a commensurate increase in revenue (*i.e.*, more staffed hours are required to perform the same hours of cases).²

However, the discrepancy between anesthesiology staffing costs and revenue is further increased by longer-than-average surgical durations, which reduce the revenue potential by lower billed units per hour of care (total ASA units per hour of clinical care).¹¹ These longer surgical durations are reflective of academic medical centers.^{10,12,26} The need for institutional support to offset net staffing costs associated with providing care in academic hospitals can be quantified from analysis of OR information systems and anesthesiology billing data. This

study presents a method to quantify the net staffing costs associated with longer-than-average surgical durations. In addition, other factors, such as payer mix and levels of compensation, that may differ among different anesthesiology departments are identified, and the effect on net costs are demonstrated.

As can be seen in table 4, estimates of net staffing costs vary tremendously depending on a variety of factors. The largest variation can be seen when the staffing compensation and payer mixes are varied (scenarios 1–3). When both are assumed to be median (scenario 1), the net staffing costs for 1 yr for hospital A (24 ORs, 12,769 cases with average duration of 2.8 h by 13 surgical services) was \$672,100. This scenario assumed that both staffing compensation and the payer mix were at the median level. However, this may not be the case for other departments. Scenarios 2 and 3 show the two extremes of staffing costs and revenue. Scenario 3, in which payer mix is favorable while compensation is relatively low, may be uncommon at academic medical centers in 2003. On the other hand, scenario 2 should be becoming more common because staffing costs continue to increase while revenue remains static. For example, the compensation data for this study were based on 2001 salary data.¹⁷ In comparison, in 2002, compensation was at least 20% higher for all ranks as compared with the median compensation used in the study, according to a survey on compensation from the Society of Academic Anesthesiology Chairs and Association of Anesthesia Program Directors (Nikoluas Gravenstein, M.D., Jerome H. Modell Professor and Chair, Department of Anesthesiology, University of Florida, Gainesville, Florida, 2002 Society of Academic Anesthesiology Chairs Salary Survey, written personal communication, October 24, 2002). On the other hand, the conversion factors have not changed or been reduced for Medicaid and are only slightly increased for Medicare.^{27,28}

In addition to the hourly staffing costs and hourly revenue, several other factors that influenced net staffing costs are less intuitive. The magnitude of the differences between the actual and national average surgical durations strongly influence net staffing costs. In scenario 4,

in which the difference between the actual and the national average was limited to 60 min rather than 180 min while keeping all other parameters the same as in scenario 1, the net staffing costs were lower.

The final factor is seen in comparing hospitals A and B (scenarios 1 and 5). Both hospitals have a similar number of hours of surgical cases and similar surgical durations, but hospital B allocates OR time among almost twice as many surgical services. Therefore, the services of hospital B have a lower OR workload per service. This difference resulted in two different types of staffing solutions during the first step of the analysis: allocating OR time and scheduling cases to maximize OR efficiency. Because hospital B had smaller services, the staffing solution for allocation resulted in ORs assigned to each service and few overutilized hours. This difference is important because overutilized OR time is more expensive than underutilized or regular hours. Because hospital B had fewer overutilized hours staffed after step 1 of the analysis, there were also fewer hours after the completion of step 2 (substituting national average durations for actual durations).

Further, the reduction in hours may not be simply a reduction in overutilized hours but a reduction in regular hours staffed.²⁹ For example, if a specific case was finished in an OR (staffed regularly until 4 PM) at 6 PM rather than 7 PM, the staff would go home at 6 PM (*i.e.*, 1 less hour staffed), and the revenue would also be reduced by 1 h. In contrast, when the surgical duration is reduced during regular hours, the revenue is still reduced, but the staffing costs may remain constant. For example, if a specific case was finished in an OR (staffed regularly until 4 PM) at 3 PM rather than 4 PM, the revenue would reflect 1 less hour, but the staffing costs would remain unchanged. Therefore, in hospital B (scenario 5), much of the reduction in hours was during regular hours without reducing the staffed regular hours (more underutilized hours) and thus a decrease in revenue without a decrease in staffing costs.

Qualitatively, hospital B has many ORs with relatively low adjusted utilizations. Because the number of anesthesia providers is set by the number of staffed ORs, reducing surgical durations in turn reduces revenue without reducing costs. In practical terms, for services with 8 h of OR time allocated but with an adjusted utilization of less than 85%, reductions in surgical duration will likely hurt the anesthesiology department financially.³⁰ In these "surgeon-friendly" OR suites, a focus on OR allocation and case scheduling (step 1 of the analysis) may be more important than longer durations.²⁹

In choosing which parameters to vary to demonstrate the different net staffing costs, we did not vary all possible parameters. The parameters that varied in the scenarios (staffing compensation level, payer mix, difference between actual and national average surgical duration, and number and volume of surgical services)

were factors that vary among groups and to which the analysis is sensitive. On the other hand, we assumed that two other parameters (the multiple of 1.75 to convert the cost of regular hours to overutilized hours and the marginal staffing with CRNAs and faculty of 1:2) would be similar among anesthesiology groups.

As noted above, overutilized hours are more expensive than regular hours. In previous studies, the value of 1.75 has been used.^{2,3} The value can be considered to represent 1.5 for the direct overtime shift differential as well as 0.25 for the indirect cost to the group for recruitment and training of new employees who replace those who leave to avoid frequent late rooms. This value seems to be consistent with our experience that academic anesthesiology departments are paying faculty and other providers additional compensation to cover noncall evening cases (*i.e.*, late rooms). In addition, the OR allocations and staffing to maximize OR efficiency are insensitive to the value of this parameter.^{14,15} With this ratio, there may be situations in which, during regular hours, hourly revenue exceeds the hourly staffing costs but falls short of the costs of overutilized hours (*e.g.*, 50th percentile costs and favorable payer mix).

As noted in Materials and Methods, the marginal staffing ratio is 1:2 with faculty anesthesiologists medically directing two CRNAs. Additional OR sites or time is often covered with this type of staffing because increasing the number of residents is not feasible. In fact, the results may underestimate the actual staffing costs due to the fact that there is a shortage of CRNAs as well as anesthesiologists.²³ When an anesthesiology department does not have enough residents, they also may not have enough CRNAs to cover all of the OR sites. In this case, the faculty anesthesiologists must personally perform anesthesia cases. The cost of the personally performed time is higher than the 1:2 cost per OR used in this study.

The net costs of staffing remote anesthetizing sites may be greater than these estimates for several reasons. First, utilization (= billed time/allocated time) is often lower than in the OR. Second, faculty anesthesiologists may not be able to simultaneously medically direct a remote case and an OR case, in which the staffing of the remote case could follow one of the following patterns: faculty alone, faculty:resident at 1:1 ratio, or faculty:CRNA at 1:1 ratio. All three cost more than the faculty:CRNA of 1:2 ratio used for this study. In this study, remote anesthesia cases were excluded from the analysis because the cases were not in the OR information database and no average surgical durations were available for comparison for all the remote cases. However, it is likely that increasing demands in many teaching hospitals for remote anesthesia services amplify the net staffing cost analyzed in this study.

In this study, we compared surgical durations by surgical procedures at the individual surgical case level. To accomplish this, we needed both the surgical CPT code

and a database with national average surgical durations listed by surgical CPT. We utilized the billing database of the anesthesiology groups because these would be readily available for other groups wanting to use a similar analysis of their practices. For the two hospitals studied, the OR information system included case durations and other data but not the coding of the surgical procedure. The billing database of the surgical services would have the surgical CPTs billed but would be available to an anesthesiology group only if a central "office" performed billing for both the anesthesiology group and all surgical groups. If an anesthesiology group provided care to multiple surgical groups with different billing services, the billing data would not be in one database and perhaps would not be available. This resulted in only one CPT for each surgical case even though sometimes more than one procedure was performed.^{31,32} In this situation, actual surgical durations that represented more than one surgical procedure were compared with a national average duration only of the primary surgical procedure, which would falsely increase the difference between the actual duration and the national average duration. To reduce the impact of this unavoidable confounding variable, two limits—60 min and 180 min—were chosen arbitrarily. Although these limits helped to reduce the confounding impact of multiple procedures, they also may have resulted in an underestimate of differences in which actual duration greatly exceeded the national duration even though only one procedure was performed.

Because there were no other publicly available databases on surgical duration, only one database was utilized to determine the national average surgical duration. We used the intraprocedure times by CPT as referenced by the Center for Medicare and Medicaid Services in their resource-based relative value system to determine fees paid to physicians. A recent review commissioned by the Center for Medicare and Medicaid Services showed that the intraprocedure times used by the Center for Medicare and Medicaid Services were similar to case durations in a large proprietary database.^{**}

In this study, the reasons behind the longer-than-average durations were not examined. Both anesthesiology and surgical training programs contribute to increased surgical duration (*i.e.*, the time during which the patient is in the OR). In comparing surgical durations of academic anesthesiology departments, the longer durations were found in hospitals where surgical residents were involved in all or almost all cases as compared with those in which there was only some or no involvement of surgical residents (2.7 *vs.* 2.1 h/case, respectively).¹² In

contrast with large academic hospitals, smaller hospitals and ambulatory surgical centers have shorter cases.¹² The results are not unexpected because one assumes that a resident learning a procedure will take longer to complete the case than a private practice surgeon. Therefore, for anesthesiology departments in hospitals that sponsor surgical training programs, longer-than-average durations are the norm. Although the anesthesiology group can try to reduce the anesthesia-controlled time associated with training its residents, the group will not be able to influence the surgery-controlled time. Therefore, the anesthesiology group incurs the increased staffing costs associated with the longer durations. As we have demonstrated in this study, the increased costs (gross costs) are offset partly by an increase in revenue. Unfortunately, as shown in this study (*i.e.*, scenarios 1, 2, 4, and 5), in many instances, the revenue is not enough to cover the costs completely. The anesthesiology group must either reduce costs or increase revenue.

As noted previously, reduction in staffing costs can be done when OR allocation and case scheduling are done to maximize OR efficiency.² The only other way to reduce costs is to reduce the compensation of the providers (*e.g.*, scenario 3 of this study). This may be possible only in markets where there is relatively high supply of providers. Unfortunately, for most markets, there remains a shortage of providers²³; therefore, reducing compensation not only threatens an academic group's ability to retain and recruit providers, but it also hinders the group's ability to cover the clinical sites that the hospital desires to operate. On the other hand, the group can try to increase revenue. If the average conversion factor can be increased (change payer mix or negotiate higher rates), the revenue increases. Increasing the value of time billed by negotiating smaller time units is also an option when working with private payers, but this strategy is not possible when dealing with Medicare or Medicaid. Finally, the group can seek supplementation of their staffing budget by the hospital or faculty practice plan. Hospitals have been known to provide support for the staffing costs to prevent reduction in the number of OR and clinical sites in operation.

Conclusion

Anesthesiology groups can incur net increased staffing costs from not allocating OR time and scheduling cases to maximize OR efficiency, and from longer-than-average surgical durations. In this study, the difference in staffing costs and revenue expected, the number of overutilized hours, and the magnitude of differences between actual and national average surgical durations influenced the groups' net staffing costs.

The authors thank Jordan Kicklighter, B.A. (Editor), and Christy Perry (Editor)

^{**} McCall N, Cromwell J, Drozd E, Hoover S: Validating intra-service time using operating room logs, Validation of Physician Time Data, prepared for Center for Medicare and Medicaid Services. Baltimore, CMS, 2001, pp 1-77. Available at: <http://cms.hhs.gov/physicians/pfs/timedata.asp>. Accessed May 29, 2003.

at the Editorial Office, Department of Anesthesiology, The University of Texas Medical Branch, Galveston, Texas, for preparing and editing this manuscript.

References

1. Abouleish AE, Zornow MH: Estimating how many anesthesia providers does our group need? *ASA Newsletter* 2001; 65:14-6
2. Abouleish AE, Dexter F, Epstein RH, Lubarsky DA, Whitten CW, Prough DS: Labor costs incurred by anesthesiology groups due to operating rooms not being allocated and cases not being scheduled to maximize operating room efficiency. *Anesth Analg* 2003; 96:1109-13
3. Dexter F, Epstein RH, Marsh HM: A statistical analysis of weekday operating room anesthesia group staffing costs at nine independently managed surgical suites. *Anesth Analg* 2001; 92:1493-8
4. Dexter F, Traub RD: How to schedule elective surgical cases into specific operating rooms to maximize the efficiency of use of operating room time. *Anesth Analg* 2002; 94:933-42
5. Strum DP, Vargas LG, May JH: Surgical subspecialty block utilization and capacity planning: A minimal cost analysis model. *ANESTHESIOLOGY* 1999; 90:1176-85
6. Strum DP, Vargas LG, May JH, Bashein G: Surgical suite utilization and capacity planning: A minimal cost analysis model. *J Med Sys* 1997; 21:309-22
7. Dexter F, Traub RD, Macario A: How to release allocated operating room time to increase efficiency: Predicting which surgical service will have the most under-utilized operating room time. *Anesth Analg* 2003; 96:507-12
8. Biernstein K: Hospital contracts, four years later. *ASA Newsletter* 2001; 65:25-7
9. Tremper KK, Barker SJ, Gelman S, Reeves J: A demographic, service and financial survey of anesthesia training programs in the United States. *Anesth Analg* 2003; 96:1432-46
10. Abouleish AE, Prough DS, Zornow MH, Hughes J, Whitten CW, Conlay LA, Abate JJ, Horn TE: The impact of longer-than-average anesthesia times on the billing of academic anesthesiology departments. *Anesth Analg* 2001; 93:1537-43
11. Abouleish AE, Prough DS, Whitten CW, Zornow MH: The effects of surgical case duration and type of surgery on hourly clinical productivity of anesthesiologists. *Anesth Analg* 2003; 97:833-88
12. Abouleish AE, Prough DS, Barker SJ, Whitten CW, Uchida T, Apfellbaum JL: Organizational factors affect comparisons of clinical productivity of academic anesthesiology departments. *Anesth Analg* 2003; 96:802-12
13. Donham RT: Defining measurable OR-PR scheduling, efficiency, and utilization data elements: The Association of Anesthesia Clinical Directors procedural times glossary. *Int Anesthesiol Clin* 1998; 36:15-29
14. Epstein RH, Dexter F: Statistical power analysis to estimate how many months of data are required to identify operating room staffing solutions to reduce labor costs and increase productivity. *Anesth Analg* 2002; 94:640-3
15. Dexter F, Macario A: Changing allocations of operating room time from a system based on historical utilization to one where the aim is to schedule as many surgical cases as possible. *Anesth Analg* 2002; 94:1271-9
16. Sperry RJ: Principles of economic analysis. *ANESTHESIOLOGY* 1997; 86:1197-205
17. Medical Group Management Association: Table 7A-C: Total compensation by rank by specialty, Academic Practice Compensation and Production Survey for Faculty and Management (2002 Report Based on 2001 Data). Englewood, Medical Group Management Association, 2002, pp 63-7
18. Medical Group Management Association: Table 21: Total compensation for non-physician providers, Academic Practice Compensation and Production Survey for Faculty and Management (2002 Report Based on 2001 Data). Englewood, Medical Group Management Association, 2002, p 104
19. Medical Group Management Association: Demographics: Faculty: 13. Rank, Academic Practice Compensation and Production Survey for Faculty and Management (2002 Report Based on 2001 Data). Englewood, Medical Group Management Association, 2002, p 27
20. Texas Department of Health: 2001 Texas Medicaid Provider Procedure Manual. Austin, Texas Department of Health, 2001, p 3
21. Biernstein K: Medicare cuts physician payments for 2002. *ASA Newsletter* 2001; 65:16-8
22. Biernstein K: Fees paid for anesthesia services: 2001 survey results. *ASA Newsletter* 2001; 65:23-5
23. Biernstein K: Survey of hospital administrators about anesthesia coverage. *ASA Newsletter* 2002; 66:29-30
24. Schubert A, Eckhout G, Tremper KK: An updated view of the national anesthesia personnel shortfall. *Anesth Analg* 2003; 96:207-14
25. Barker SJ: Lord or vassal? Academic anesthesiology finances in 2000. *Anesth Analg* 2001; 93:294-300
26. Abouleish AE, Prough DS, Whitten CW, Zornow MH, Lockhart A, Conlay LA, Abate JJ: Comparing clinical productivity of anesthesiology groups. *ANESTHESIOLOGY* 2002; 97:608-15
27. Borges W: Medicaid cuts. *Tex Med* 2003; 99:24-8
28. Biernstein K: 2003 Medicare anesthesia conversion factor is \$17.05. *ASA Newsletter* 2003; 67:23-5
29. Dexter F, Abouleish AE, Epstein RH, Whitten CW, Lubarsky DA: Use of operating room information system data to predict the impact of reducing turnover times on staffing costs. *Anesth Analg* 2003; 97:1119-26
30. Dexter F, Macario A, Manberg PJ, Lubarsky DA: Computer simulation to determine how rapid anesthetic recovery protocols to decrease the time for emergence or increase the phase I post anesthesia care unit bypass rate affect staffing of an ambulatory surgery center. *Anesth Analg* 1999; 88:1053-63
31. Strum DP, May JH, Sampson A, Vargas LG, Spangler W: Estimating times of surgeries with two component procedures. *ANESTHESIOLOGY* 2003; 98:232-40
32. Dexter F, Macario A: What is the relative frequency of uncommon ambulatory surgery procedures in the United States with an anesthesia provider? *Anesth Analg* 2000; 90:1343-7