Holiday and Weekend Operating Room On-Call Staffing Requirements

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BACKGROUND: Every facility that performs cases on holidays has in some way decided on its operating room (OR) and anesthesia staffing for holidays. Previous studies have not examined how best to calculate appropriate holiday staffing.
METHODS: We analyzed weekend and holiday data from a university hospital.
RESULTS: There were high rank correlations between the number of cases starting during each 12-h period of a holiday, the total hours of OR time used, and the patients and surgeons waiting for cases to start. Weekend and holiday 12-h periods were divided into 8 categories (e.g., Saturday 7:00 AM to 7:00 PM). There was perfect rank correlation between the mean number of cases starting during each 12-h period and appropriate staffing during the 12-h period, whether quantified by total hours of cases or by the under-utilized and over-utilized OR time resulting from staffing decisions.
CONCLUSIONS: The number of cases starting during each period of a holiday is a statistically valid end point for OR managers to use to evaluate how busy holidays are relative to weekend days. To be useful, the statistic must be combined with mathematically valid assessments of appropriate weekend staffing on-call, whether in-house, or from home.

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Every facility that performs surgical cases on weekends and holidays has somehow or other decided on its OR staffing for weekends and holidays.

Previous studies have established valid methods for deciding on staffing for surgical cases during weekdays (1,2) and weekends (3,4) (Table 1). Staffing, in this context, refers to the number of ORs planned to be run simultaneously or, if desired, the number of anesthetics planned to be performed simultaneously. If too few in-house staff are provided, either cases will be delayed or on-call OR nurses and anesthesia providers must come from home. On the other hand, scheduling more staff than are needed incurs unnecessary costs.

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Deciding on OR staffing for holidays can be more complicated than for workdays and weekends because there are fewer historical values to use. In our experience, OR managers sometimes plan staffing for holidays on the basis of staffing for either Saturday or Sunday. Some managers review prior holidays to judge whether or not the days were busy. We are not aware of previous work assessing the validity of this approach. In this study, we consider how to quantify holiday workload: numbers of cases, hours of cases, patient waiting, and/or staffing requirements. The methods can be applied equally well to OR information system, anesthesia information system, or anesthesia billing data.

METHODS

Between July 1, 1996 and November 30, 2005, 179,010 OR cases were performed at the studied university hospital in the United States with 32 ORs. The dates and times of patients' entrances into and exits from ORs were obtained for the 6,308 weekend and holiday OR cases during the period. Also obtained for each case was the date and time when the surgeon reported that he or she and the patient were available. There were 9 holidays per year, with Thanksgiving and Christmas holidays each 2 days long. A case was considered to start when the patient entered his or her OR.

Weekend Staffing to Start Cases Without Delay on ≥95% of Days

The methodology for deciding on appropriate weekend staffing has been reviewed (4). Table 1 is an

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Table 1. Example of Weekend Staffing—Saturdays

Start and end times of shifts considered		Number of teams chosen to work each shift to assure future risk of under-staffing ≤ 5% of days	Number of teams in-house to minimize staffing costs
7:00 AM	7:00 AM	0	0
7:00 AM	3:00 PM	3	1 of 3
7:00 AM	5:00 PM	0	0
7:00 AM	7:00 PM	0	0
7:00 AM	9:00 PM	0	0
7:00 AM	11:00 PM	0	0
11:00 AM	7:00 PM	0	0
11:00 AM	11:00 PM	0	0
11:00 PM	7:00 AM	0	0
3:00 PM	11:00 PM	3	1 of 3
3:00 PM	7:00 AM	0	0
5:00 PM	7:00 AM	0	0
7:00 PM	7:00 AM	0	0
9:00 PM	7:00 AM	0	0
11:00 PM	7:00 AM	3	1 of 3

Methodology to decide on appropriate weekend staffing has been studied (3,5) and reviewed (4). This table is an example of such a result.

example, showing a result in applying the methodology to the data from the studied university hospital.

Appropriate total numbers of OR teams on-call in-house and on-call from home can be determined for weekends by evaluating staffing at 1-h periods and assuring that all cases can be started without delay on at least 95% of days (3,4). Specifically, adequate staffing was considered to be that providing 95% confidence of no more than 1 day in 20 when insufficient OR teams would be available to care for every case during the hour that it previously was performed (3). Proposed staffing solutions were every combination of the 15 shifts listed in the first two columns of Table 1. For every proposed staffing solution, the number of OR teams was calculated that would be available for every hour of the 24-h period of interest. One team was needed for each OR with a case. The calculated number of OR teams at each hour was compared with the number of teams that were actually needed at that hour during each 24-h period of the most recent 3-yr of historical data (December 1, 2002 to November 30, 2005). If during any hour of a 24-h period a proposed staffing solution would not have provided adequate staffing, then one or more cases would have been delayed in starting. The proposed staffing solution was considered inadequate for that 24-h period. If the number of inadequate 24-h periods exceeded the statistically determined cut-off value, then that proposed staffing solution was discarded as unacceptable. Statistical assumptions (5) were satisfied.

Every acceptable combination of potential staff schedules was then considered for the staff being on-call from home (e.g., with pager) or being scheduled to work in-house (4). Using the OR workload data, the cost of each combination was calculated. Parameters used were \$1400 to staff an OR for 8 h with staff scheduled in-house, \$200 for an OR team to be on-call from home for 24 h, and \$300 per hour for at least 4 h when a team is called in from home. There was at least 1 OR team in house at all times. The lowest cost staffing solution was chosen.

Holiday and Weekend Workload and Staffing Analyzed Like Weekdays

Instead of analyzing each hour, 12-h periods were used for the holiday analysis because of smaller sample sizes (Table 2).

Our hypothesis was that the mean number of cases started during each 12-h period could be used to assess appropriate relative staffing among the 12-h periods. To test this hypothesis, we needed to measure appropriate staffing. Holidays and weekends were analyzed as if each received a weekday OR allocation with staffing in-house in 12-h increments (column E) (1,2).

Under-utilized OR time was considered the time during which an OR is staffed with personnel who are scheduled to work in-house, but the OR is not being used for surgery. Over-utilized OR time refers to the time during which an additional OR is opened, staffed by individuals called from home. Calculations were performed on the basis of minimizing the weighted combination of under-utilized OR time (too much staffing planned) and over-utilized OR time (too little staffing planned). Thus, under-utilized and over-utilized times are both based on "staffed ORs," which is based on the number of ORs planned to be run simultaneously for the day with staff who are scheduled in-house.

The hours of under-utilized OR time for each 12-h period was calculated as [(12 h × the number of staffed ORs) – (the day's total OR time used during the 12-h period)], or zero if the difference was negative (1). If excessive personnel are made available to staff ORs that are not used, the under-utilized OR time results in unnecessary cost.

The hours of over-utilized OR time for each 12-h period was calculated as [(the day's total OR time used during the 12-h period) – (12 h × the number of staffed ORs)], or zero if the difference was negative

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Table 2. Holiday and Weekend Workload and Staffing

A	B	C Days	D Cases starting during period	E Potential in-house OR teams	F Under-utilized (h)	G Over-utilized (h)	H Inefficiency vs. Best Choice (hr) Ratio 2.0	I Inefficiency vs. Best Choice (hr) Ratio 4.0
7:00 AM to 7:00 PM	Holiday Mon, Fri	54	4.7 ± 0.2	0	0.0 ± 0.0	14.3 ± 0.9	17 ± 2	44 ± 4
				1	3.1 ± 0.4	5.4 ± 0.6	2 ± 1	11 ± 2
				2	10.4 ± 0.7	0.7 ± 0.2	BEST	BEST
				3	21.8 ± 0.9	0.0 ± 0.0	10 ± 1	9 ± 1
	Sat	491	4.3 ± 0.1	0	0.0 ± 0.0	12.1 ± 0.3	12 ± 0	34 ± 1
				1	3.9 ± 0.1	3.9 ± 0.2	BEST	5 ± 1
				2	12.5 ± 0.2	0.6 ± 0.1	2 ± 0	BEST
				3	24.0 ± 0.3	0.0 ± 0.0	12 ± 0	9 ± 0
	Holiday Tue–Thu	30	3.9 ± 0.3	0	0.0 ± 0.0	10.8 ± 1.1	10 ± 2	27 ± 5
				1	4.8 ± 0.6	3.6 ± 0.7	BEST	3 ± 2
				2	13.8 ± 1.0	0.6 ± 0.2	3 ± 1	BEST
				3	25.2 ± 1.1	0.0 ± 0.0	13 ± 2	9 ± 1
	Sun	491	3.6 ± 0.1	0	0.0 ± 0.0	10.0 ± 0.3	10 ± 0	24 ± 1
				1	4.8 ± 0.1	2.8 ± 0.2	BEST	1 ± 1
				2	14.3 ± 0.2	0.3 ± 0.1	4 ± 0	BEST
				3	26.0 ± 0.3	0.0 ± 0.0	16 ± 0	11 ± 0
7:00 PM to 7:00 AM	Sat	491	2.2 ± 0.1	0	0.0 ± 0.0	7.5 ± 0.2	5 ± 0	16 ± 1
				1	6.4 ± 0.1	1.9 ± 0.1	BEST	BEST
				2	16.7 ± 0.2	0.2 ± 0.0	7 ± 0	4 ± 0
				3	28.5 ± 0.2	0.0 ± 0.0	18 ± 0	15 ± 1
	Holiday Mon, Fri	54	2.1 ± 0.2	0	0.0 ± 0.0	6.7 ± 0.6	4 ± 1	13 ± 2
				1	6.7 ± 0.5	1.4 ± 0.2	BEST	BEST
				2	17.4 ± 0.6	0.0 ± 0.0	8 ± 1	5 ± 1
				3	29.3 ± 0.6	0.0 ± 0.0	20 ± 1	16 ± 2
	Sun	491	1.7 ± 0.1	0	0.0 ± 0.0	5.6 ± 0.2	1 ± 0	10 ± 1
				1	7.6 ± 0.1	1.2 ± 0.1	BEST	BEST
				2	18.5 ± 0.2	0.1 ± 0.0	9 ± 0	7 ± 0
				3	30.4 ± 0.2	0.0 ± 0.0	20 ± 0	18 ± 0
	Holiday Tue–Thu	30	1.6 ± 0.2	0	0.0 ± 0.0	5.1 ± 0.7	0 ± 1	8 ± 2
				1	7.9 ± 0.5	1.0 ± 0.4	BEST	BEST
				2	19.0 ± 0.7	0.1 ± 0.1	9 ± 1	7 ± 2
				3	30.9 ± 0.7	0.0 ± 0.0	21 ± 1	19 ± 2

Data are reported as mean ± SEM. "OR" refers to operating room. "Under-utilized (h)" refers to hours of under-utilized OR time, as defined in the Methods. "Over-utilized (h)" refers to the hours of over-utilized OR time. "Inefficiency" refers to the inefficiency of use of OR time in units of hours.

(1). These excess hours represent the cost of brining in extra staff, beyond those initially scheduled, to meet the demands for OR time.

The hours of over-utilized OR time with 0 ORs staffed is the same as the total hours of cases during the 12-h period.

The mean and standard errors among 12-h periods of the hours of under-utilized and over-utilized OR time are given in columns F and G.

The inefficiency of use of OR time in units of hours was calculated for each 12-h period as the under-utilized OR time + (ratio) × over-utilized OR time, where the ratio equals the relative cost of an hour of over-utilized OR time to an hour of under-utilized OR time (1,2). The ratios used were either 2.0 or 4.0. In the context of holiday and weekend staffing, the cost of an hour of over-utilized OR time can refer to more than the cost of having a staff member called in from home to do a case as compared to being scheduled in-house but idle. There can also be a cost from the patient and surgeon waiting. The ratio of 2.0 results in there being under-utilized OR time on approximately 2/3 of days and over-utilized OR time on approximately 1/3 days (1). Thus, the ratio of 2.0 provides staffing based approximately on the 66th percentile of workload (1). The ratio of 4.0 provides staffing based approximately on the 80th percentile of workload (1). These percentiles are approximate, because staffing options used in the calculations were limited to the 4 discrete choices of 0, 1, 2, or 3 ORs (column E) (2).

The number of staffed ORs resulting in the minimum sum, among 12-h periods, of the inefficiency of

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use of OR time is listed as "BEST" in columns H and I. The difference was taken for each period between the period's inefficiency of use of OR time using the number of listed OR teams in column E and the period's inefficiency of use of OR time using the BEST OR staffing. The mean ± SE of these differences in hours are reported in columns H and I.

Six categories were created on the basis of the study hospital's current staffing: Saturday, Sunday, or Holiday and 7:00 AM to 7:00 PM or 7:00 PM to 7:00 AM. On the basis of the judgment of the hospital's OR and anesthesia group managers, holidays were divided into two categories: (a) Mondays or Fridays and (b) Tuesdays, Wednesdays, or Thursdays (columns A and B). These categories were suitable for the study hospital, but likely will not be applicable to some other hospitals (e.g., in countries where many holidays are not celebrated on days contiguous to weekends). The number of cases starting during each period was calculated. The "starting" time in column D refers to when the patient entered his or her OR.

Correlations Between Cases Started During Each Period and Other Measures of Workload

Concurrent validity reflects whether a scale performs as expected in relation to other meaningful variables that are collected at the same time. Table 2 evaluates correlations between the mean numbers of cases started during each 12-h period and staffing calculated as if holidays and weekends were weekdays. Table 3 was created to compare the daily numbers of cases started to other variables, specifically hours of over-utilized OR time with 0 ORs planned (i.e., total hours of OR cases), hours of over-utilized OR time with 1 OR planned, and patient and surgeon waiting times. Spearman correlations were reported with standard errors calculated asymptotically (StatXact-7, Cytel, Cambridge, MA).

"Cases waiting" were calculated for Table 3 as the mean of the number of cases waiting to start among all 720 min of each 12-h period. Waiting times were measured from when the surgeon reported that he or she and the patient were available until the case entered its OR.

RESULTS

Table 1 gives an example of how to provide staffing to meet the acceptable risk of not being able to start each case as promptly as it had been started previously. Three teams, each available for 24 h, provided the least number of staff hours on Saturdays. Equivalently, three teams could each work: 7:00 AM to 3:00 PM, 3:00 PM to 11:00 PM, and 11:00 PM to 7:00 AM (column 3). Every combination of these nine staff schedules was considered with the team being on-call from home (e.g., with pager) or being scheduled to work in-house (4). The lowest cost staffing solution was the one shown in column 4.

Table 2, in contrast, analyzes holiday and weekend staffing as if the days were weekdays. The analysis

Table 3. Spearman's Rank Correlations Among Variables

Holiday half days (N = 168)	
Cases starting versus cases waiting	0.60 ± 0.05
Cases starting versus ORs in use	0.86 ± 0.02
Cases starting versus over-utilized OR time with 1 OR in use	0.78 ± 0.04
Cases waiting versus ORs in use	0.68 ± 0.05
Cases waiting versus over-utilized OR time with 1 OR in use	0.65 ± 0.05
Holiday and weekend half days (N = 2132)	
Cases starting versus cases waiting	0.63 ± 0.01
Cases starting versus ORs in use	0.82 ± 0.01
Cases starting versus over-utilized OR time with 1 OR in use	0.74 ± 0.01
Cases waiting versus ORs in use	0.70 ± 0.01
Cases waiting versus over-utilized OR time with 1 OR in use	0.70 ± 0.01

"ORs" represents operating rooms. The results are reported ± SE of the correlation.

balanced the costs of having idle staff in-house versus having OR nurses and anesthesia providers come from home and/or surgeons and patients waiting for cases to start. Eight categories of weekend, holidays, and time of day were sorted in descending sequence of the mean number of cases starting during the listed 12-h period (column D). This descending sequence precisely matched the descending sequence of appropriate staffing, whether quantified by total hours of cases (over-utilized OR time with 0 ORs planned) (columns E and G) or by the under-utilized and over-utilized OR time resulting from staffing decisions (columns H and I). Thus, the mean number of cases started had a perfect Spearman's rank correlation with the staffing to care for the patients.

Figure 1 shows the relationship between the daily numbers of cases started and numbers of hours of OR cases for the 168 holiday days. Each point shows the number of cases started during a 12-h period of a holiday and the number of hours of OR cases performed during the 12-h period. A LOESS (6) smooth line was drawn (7) to indicate the ordered relationship between the cases starting and hours of cases. The data were then jittered along the horizontal axis to make them visible.

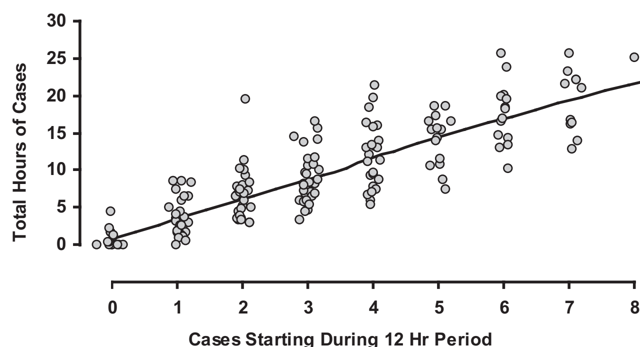

Figure 1. Operating room hours of cases being performed during each 12-h period of a holiday versus numbers of cases scheduled during the period.

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If a case started before the beginning of a 12-h period and continued into the period, then the case was not counted as starting during the period. However, the time of the case performed within the period was included along the vertical axis. The reason is that holiday OR teams can be busy with cases that started before the start of the 12-h period. All cases performed, at least in part, during a holiday period were included, regardless of whether the case was very brief or long.

The positive correlation suggested by Figure 1 was confirmed statistically (Table 3). The table also shows that there was significant correlation between cases starting during each 12-h period and the number of minutes that a patient or surgeon waited during each period.

The mean number of cases starting during each 12-h increment (e.g., Table 2 column D) does not reveal appropriate staffing. OR managers are provided insight into appropriate staffing for the four holiday categories on the basis of the appropriate weekend staffing for each of the four weekend categories (e.g., Table 1). For example, knowing that holidays on Tuesdays–Thursdays average 3.9 cases from 7:00 AM to 7:00 PM does not help because required staffing depends on the overlap and urgencies of those cases. Knowing that a Tuesday–Thursday holiday workload is in between that of a Saturday and a Sunday reveals appropriate staffing.

DISCUSSION

Every facility that performs surgical cases on weekends and holidays has, somehow or other, made a decision regarding appropriate OR and anesthesia staffing. "Appropriate" should be defined with sufficient precision that it is possible, in retrospect, to evaluate the quality of the managers' decisions. Whereas this is possible when staffing requirements are calculated using methods such as those given in Table 1, it is not possible on the basis of the average daily numbers of cases. Nevertheless, calculating and monitoring numbers of cases starting during each hour of the holiday is simple to implement. We showed that this statistic is a valid and useful end point for managers to use when evaluating how busy holidays are relative to weekend days.

Results were limited to weekend staffing adjusted using valid statistical methods (3–5) (Table 1). In a previous case series, some cost-conscious managers reduced staffing to the point that the risk was more than 6% of having too few OR teams available to start cases as promptly as started previously (5). A comparison of results of Tables 1 and 2 explains the differences. Appropriate Saturday staffing to prevent rare events of having insufficient staffing (Table 1) results in substantial under-utilized OR time (Table 2). Whereas Table 1 shows staffing for the >95th percentile of workload, Table 2 shows staffing for the ≅66th and ≅80th percentiles of workload. Managers should be wary that having sufficient staff on average (Table 2) may not be sufficient to handle peak workload (Table 1). Analyses in Table 1 also explicitly consider the costs of being scheduled in-house versus on-call from home (4).

Assessments of the validity of use of numbers of cases as a surrogate for relative OR workload among holiday and weekend categories were limited to average OR workloads (Tables 2 and 3). Sample sizes were insufficient to assess peak (>95%) workload as in Table 1. Whereas 3 yr of data for Table 1 provided 156 Saturdays, there were just 18 Monday or Friday holidays and 9 Tuesdays–Thursday holidays. There is a limitation at all hospitals as holidays are, by definition, holidays. On the other hand, by the same argument, methodology for holidays should be limited and easy to apply. At the study hospital, holiday cases represented just 0.09% of all OR cases and 2.4% of days.

Data used for scientific investigation were from an OR information system at one hospital. The same methodology can be performed, and often will be in practice, using anesthesia information management system data or anesthesia billing data. For most staffing analyses, the data from OR information systems, anesthesia information systems, or anesthesia billing systems are interchangeable (8,9). When appropriate, the data may include obstetrics cases, intubations, and other non-OR cases. Likewise, analyses were conducted by pooling specialties, since the OR nurses, anesthesia residents, and certified registered nurse anesthetists working weekends and holidays cared for all patients. The identical analyses can be subdivided by specialty if separate call teams are staffed for different categories of patients (e.g., cardiac surgery or liver transplantation).

REFERENCES

1. Strum DP, Vargas LG, May JH. Surgical subspecialty block utilization and capacity planning. A minimal cost analysis model. Anesthesiology 1999;90:1176–85.
2. Dexter F, Epstein RH, Marsh HM. Statistical analysis of weekday operating room anesthesia group staffing at nine independently managed surgical suites. Anesth Analg 2001;92:1493–8.
3. Dexter F, Macario A, Traub RD. Statistical method using operating room information system data to determine anesthetist weekend call requirements. AANA J 2000;68:21–6.
4. Dexter F, O'Neill L. Weekend operating room on-call staffing requirements. AORN J 2001;74:666–71.
5. Dexter F, Epstein RH, Marsh HM. Costs and risks of weekend anesthesia staffing at six independently managed surgical suites. AANA J 2002;70:377–81.
6. Cleveland WS. Visualizing data. Murray Hill, NJ: Hobart Press, 1993:93–101.
7. Systat Software. Systat 11 statistics, Vol. III. Richmond, CA: Systat Software, Inc., 2004:391–404.
8. Junger A, Benson M, Quinzio L, et al. An anesthesia information management system as a tool for controlling resource management of operating rooms. Meth Inform Med 2002;41:81–5.
9. Dexter F, Epstein RH. Optimizing second shift OR staffing. AORN J 2003;77:825–30.

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