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Evaluation of an Advance Surgical Scheduling System

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Utilization of the surgical suite is of significant concern to administrators because of the high costs associated with this facility. Scheduling systems, which control the flow of patients into the surgical arena, are frequently cited as a primary means of improving resource utilization. The objective of the research reported herein was to test the hypothesis that the implementation of a centralized advance surgical scheduling system is associated with a significant improvement in operating room (OR) team utilization rate. Data were collected at a test hospital and at a control hospital for three months prior to implementation of a scheduling system at the test hospital, and for an additional three months starting nine months after implementation. The mean OR team utilization rate at the test hospital rose 12% from 0.68 prior to implementation to 0.77 postimplementation. The mean OR team utilization rate at the control hospital fell 8%, from 0.78 preimplementation to 0.73 postimplementation. The research hypothesis was supported using multiple regression, which controlled for various intervening variables that could affect utilization rate independently of the scheduling system. A literature review showed that experimental designs such as the one used in this study have not previously been used to evaluate scheduling systems in hospital settings, despite the increasing need to justify the purchase and implementation of such systems.

INTRODUCTION

The overall objective of the research reported here was to evaluate the effect on operating room (OR) utilization rate of implementing a centralized, advance surgical scheduling system in a Veterans Administration Medical Center (VAMC). OR utilization rate is an important resource utilization measure for hospital administrators, given that high construction and operational costs are associated with the surgical suite. Rinde and Blakely[1] reported in 1974 that surgical suite construction cost per square foot is the highest of any hospital department, and that operational costs typically make the surgical suite the fifth most expensive hospital department to operate (behind Nursing, Laboratory, Radiology, and Dietary). In order to make the most efficient use of this costly resource, administrators are usually interested in finding means to increase the utilization rate of the surgical

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suite and its associated resources (e.g., preoperative holding area, recovery room, blood bank, sterile supply). Rinde and Blakely[1] further cite a hospital's case scheduling system as one of the most significant influences on surgical suite effectiveness and efficiency.

A 1984 study of the surgical suite utilization rate at the study VAMC revealed an average utilization rate over a 3-month period of 64%. Rinde and Blakely's survey of 12 member hospitals of the Chicago Hospital Council showed an average OR utilization rate of 53%. Despite these low figures, the surgical suite literature indicates that utilization rates of 80 to 85% are achievable through aggressive management.[2–6]

An analysis of the method used in 1984 by the study VAMC for scheduling surgical cases identified the method as a likely contributor to the low utilization rates. The VAMC employed a decentralized, block scheduling system to advance schedule patients for surgery. (In a "block" scheduling system, a weekly block of time is assigned until some designated cut-off time to a specific surgeon or group of surgeons for their exclusive use. This contrasts with nonblock scheduling systems, in which cases are scheduled on a first-come, first-served basis.) The decentralized nature of the scheduling system precluded the OR Director from aggressively controlling the utilization of the suite. Under the scheduling system then in use, the chief resident of each surgical specialty was responsible for advance scheduling that specialty's cases. The OR was not notified of these advance scheduled cases until the day before the surgeries were scheduled to be performed. At that point, little time was available to make arrangements to fill any unused portions of the block. Furthermore, since the residents had no clear incentive to maximize OR utilization, the resultant surgical schedule was frequently not as full as it could have been.

A new scheduling system was proposed whereby a Scheduling Coordinator would be hired to work in the OR. This coordinator would be responsible for advance scheduling patients for surgery at the same time the surgeon reserved a bed through Admitting. As a given day approached, the Coordinator would be able to tell whether or not the schedule was filling up, and could alert the responsible specialties of any unused time. In addition, a 48-hour release time was recommended for each specialty's unused block time, thereby giving the OR Director and the Scheduling Coordinator additional time to make arrangements to schedule unused time. This time could be filled either by previously unscheduled in-house patients requiring surgery, or by outside patients contacted from a waiting list.

The Medical Center Director agreed to provide the necessary resources for the proposed scheduling system, with the stipulation that the system be formally evaluated for its effect on OR utilization rate after being in use approximately one year. The purpose of the research reported here, which evolved from the Director's stipulation, was to test the hypothesis that the implementation of a centralized, advance surgical scheduling system is associated with a significant improvement in the utilization of staffed operating rooms.

LITERATURE REVIEW

A review of the literature on surgical demand scheduling by Magerlein and Martin[7] points out that most reported studies attempt to show that the advance scheduling of patients for surgery has a significant effect on the performance of the surgical suite. However, problems reported in the literature reviewed by the authors included (1) the studies describe an existing scheduling system, make recommendations for improving it, but then do not evaluate the results of actually implementing those recommendations; (2) the study periods are usually of fairly short duration (e.g., four to six weeks); and (3) the performance measures used to evaluate the scheduling system are usually limited in number. As a result, no solid empirical evidence exists to support the positive effects claimed for surgical scheduling systems.

A review of the literature appearing after the Magerlein and Martin study identified no formal scheduling system evaluations. The trade journal of literature tends to describe first a particular problem in a particular hospital, then describes in general terms that hospital's solution to the problem, and concludes with some general recommendations for use by other hospitals.[3,8–12] Very little data are provided in these articles, and those data that are provided are not the result of formal evaluation.

Several other articles in the health care literature discuss the advantages of computer-supported scheduling in the OR. Again, however, no data are provided to substantiate the claims that these systems can improve surgical suite utilization.[5,13–14]

An exception to these general descriptive approaches to surgical scheduling systems is a compilation of papers presented at a 1984 Conference on "Computerized Operating Room Scheduling and Reporting," sponsored by the Hospital Management Systems Society of the American Hospital Association. The papers from this conference provide some relatively detailed descriptions of scheduling and information systems implemented in specific hospitals. However, formal evaluations of the featured systems are still notably absent.[2,4,15–17]

In summary, no formal, controlled evaluations of alternative scheduling methodologies have been reported. Thus, it is not possible to know whether the specific intervention described in any of the articles actually caused the desired effect. Given the significant costs associated with the purchase and implementation of most scheduling systems, it is important that the benefits of such systems be explicitly determined. Hospitals today cannot afford to implement new systems based simply on their conceptual appeal. The significance of the research reported here lies not only in the evaluation of a particular scheduling system but also in the demonstration of the importance of conducting rigorous evaluations of such systems generally.

RESEARCH DESIGN AND DATA COLLECTION

The research design employed in this study was a nonequivalent untested control group design with pre-test and post-test. A second VAMC was selected to serve as the control hospital. The control VAMC was selected on the following characteristics: (1) use of a surgical scheduling system similar to the one used at the test VAMC prior to implementation of the new system; (2) similarity in size; (3) similarity in types of patients treated; and (4) willingness to participate in the study.

Table 1 indicates that the two VAMCs are fairly similar in terms of size and types of patients treated. However, there appears to be a rather significant difference in the occupancy rates between the two facilities. This difference was taken into consideration in the analysis of the results.

Data were collected at both VAMCs for the three months immediately prior to

Table 1. Medical Center Descriptive Data: FY 1985

	Test VAMC	Control VAMC
Medical beds	130	150
Medical pts. treated	7800	5900
Avg. occupancy—Medical	0.84	0.70
Surgical beds	100	130
Surgical pts. treated	3500	2700
Avg. occupancy—Surgical	0.77	0.69
Operating rooms	7	6
Affiliated with Med. School?	Yes	Yes

implementation of the scheduling system (May, June, and July of 1985) in the test VAMC and were also collected for the same three-month time period nine months following implementation (May, June, and July of 1986). Waiting for nine months following implementation in order to collect post-test data allowed for (1) sufficient opportunity for the surgical staff at the test VAMC to become familiar with the new scheduling system and to work out any problems; and (2) elimination of any seasonal variations in the performance measures (data were collected during the same three months for both years).

The objective of the research was to determine the effect of the scheduling system implemented at the test VAMC on OR utilization. However, factors other than the scheduling system can affect OR utilization and need to be considered in the analysis. An explanation of these factors and their expected relationships to OR utilization follows.

Average Case Duration

Studies have shown that the duration of a case and when it is scheduled can have a significant effect on utilization rate.[18,19] The precise effect of case length on utilization rate depends on how the OR chooses to schedule its cases. To the extent that long cases use up substantial OR time without experiencing the "down-time" that is inevitable between the scheduling of consecutive, shorter cases, a hospital which performs many complex cases might experience a higher utilization rate than a hospital which performs many shorter, more routine cases. However, to the extent (1) longer cases do not take up the entire day; and (2) the surgical director is reluctant to schedule shorter cases at the end of the day to fill in this time, a hospital might experience a relatively low OR utilization rate if it has many long cases. For data collection purposes, the duration of a case was defined as the time from the start of case set-up to the end of case clean-up.

Surgery Bed Occupancy Rate

This variable is intended to represent the demand for OR time. At any given point in time, occupancy rate is not likely to be a good measure of demand; but if the rate changes significantly over time, such a change may affect the utilization of the OR. The average occupancy rate at the test VAMC prior to implementation of the scheduling system was 77%; at the control VAMC it was 69%. Decreases in occupancy to values considerably below these averages on a given day(s) could represent a decrease in demand for surgery, which would result in a decrease in demand for OR time. Similarly, increases in occupancy to values above these averages could represent an increase in demand. Alternatively, such increases could represent an increase in the length of stay of surgery patients. Under the latter situation, an increase in surgery bed occupancy would not affect OR utilization, if bed availability diminishes and patients demanding surgery cannot be admitted.

Number of Overtime Cases

The number of overtime cases is defined as the number of cases which start before the scheduled end of working hours in the OR, but finish after the scheduled end of working hours. The greater the number of these cases, the higher the utilization of the OR is likely to be, because there is no gap of unused time between the last scheduled case of the day and the end of scheduled hours. The number of overtime cases is likely to be a function of the number of emergent cases treated by a hospital and/or OR management's philosophy regarding the use of overtime.

Number of Cancelled Cases

This variable contains those cases that are cancelled after the final OR schedule for a day's surgeries has been prepared (i.e., cases that are cancelled within approximately 20 hours prior to scheduled surgery). Most of these last-minute cancellations are for reasons such as patient no-shows, surgeon unavailability, additional tests required, medical reasons (e.g., complications), emergency case done instead, or prior case lasted longer than expected. To the extent that there are a large number of cancellations on any given day, the OR utilization rate will be low, unless additional patients can be added to the schedule at the last minute.

Number of Add-on Cases

This variable contains those cases that are added to the OR schedule after the schedule for a day's surgeries has been finalized. These cases include urgent and emergent cases, as well as some elective patients already in the hospital who are added to the schedule.

Data on the above variables, as well as on OR team utilization rate, were collected at the two VAMCs during the pre- and postimplementation time periods. The OR team utilization rate for a given day was defined as

$$\frac{\text{Actual Time OR Teams Used}}{\text{Total Time OR Teams Available}}$$

during regularly scheduled working hours. The numerator, "Total Time OR Teams Used," is a sum of the case times for the day, where time includes the time from the start of case set-up until the end of case clean-up. Procedure times preceding the start of the schedule (7:30 a.m.) and following the end of the schedule (3:30 p.m.) are not included in the calculation of utilization rate.

The calculation of the denominator of utilization rate is

$$\begin{matrix}\text{Number of Teams} \\ \text{Available for the Day}\end{matrix} \times \begin{matrix}\text{Scheduled Time for the Day} \\ \text{Per Team}\end{matrix}$$

The number of teams is used as the basis for determining the total OR time available rather than the number of operating rooms, because in both the test and the control VAMCs, staffing was a resource constraint. Both facilities had more operating rooms than they could use concurrently. Failure to use all of the available rooms was not a function of the scheduling system used, but was instead a function of the number of teams available on any given day. Therefore, to evaluate the effect of the scheduling system on utilization rate, the denominator was calculated using the number of teams available.

The number of teams available on any given day during the two data collection periods varied from four to six (mean of 4.6) at the control VAMC, and from five to seven (mean of 5.8) at the test VAMC. The nursing directors of the ORs at both hospitals were interviewed to ensure that daily fluctuations in available staffing were not the result of staffing adjustments due to changes in demand. Obviously, any such adjustments could improve utilization of the available teams (e.g., if staff were sent home because of low volume on any given day)—an improvement that could not be attributed to the type of scheduling system used. Both directors indicated that daily fluctuations in available staffing were not due to changes in case volume, but were instead due to such factors as annual leave and sick leave of the nursing staff.

The data required for the study were obtained from two primary sources at each VAMC: (1) a data collection form completed by the OR nursing staff each day for each operating room; and (2) the daily "Gains and Losses" sheet produced by each Admitting Department.

OR data Collection Form

Forms were posted outside each of the operating rooms, and the following data items were collected on each completed case:

1. room number
2. time first nurse entered to set up case
3. time last nurse left following clean-up
4. specialty of surgeon performing case

Each data collection coordinator also collected daily data on:

1. number of teams available
2. start and stop times for the day's schedule (e.g., 7:30 a.m. to 3:30 p.m.)
3. number of cancellations
4. number of add-ons

"Gains and Losses" Sheet

The Admitting Department in each VAMC produces daily statistics on all admissions to, discharges from, and transfers between the inpatient wards. Because each ward is designated as either a medical, surgical, or psychiatric ward, data on the occupancy rate, by service, could be obtained directly from these sheets.

STATISTICAL ANALYSIS

The hypothesized effect of the centralized scheduling system is presented in Fig. 1. The test VAMC was expected to experience a significantly greater increase in its OR utilization rate vis-a-vis the control VAMC between pre- and postimplementation. That is, the slopes of the two lines depicted in Fig. 1 should differ significantly, with the line representing the change in the test VAMC's utilization rates having a larger, more positive slope than the line representing the change in the control VAMC's utilization rate. In other words, the effect of time period on utilization rate should depend on the medical center.

The basis for testing the research's hypothesis is the following multiple regression model:

$$Y = \beta_0 + \beta_1 X_{i1} + \beta_2 X_{i2} + \beta_3 X_{i1} X_{i2} + \beta_4 X_{i3} + \beta_5 X_{i4} + \beta_6 X_{i5} + \beta_7 X_{i6} + \beta_8 X_{i7} + \epsilon_i, \quad (1)$$

where,

i = a day within the data collection period for one of the hospitals

$Y = \log \dfrac{\text{utilization rate}}{1 - \text{utilization rate}}$

X_1 = time period (0 for preimplementation, 1 for postimplementation)

X_2 = medical center (0 for control, 1 for test)

$X_1 X_2$ = interaction term

X_3 = average case length

X_4 = number of overtime cases

X_5 = surgical service bed occupancy rate

X_6 = number of cancelled cases

X_7 = number of add-on cases

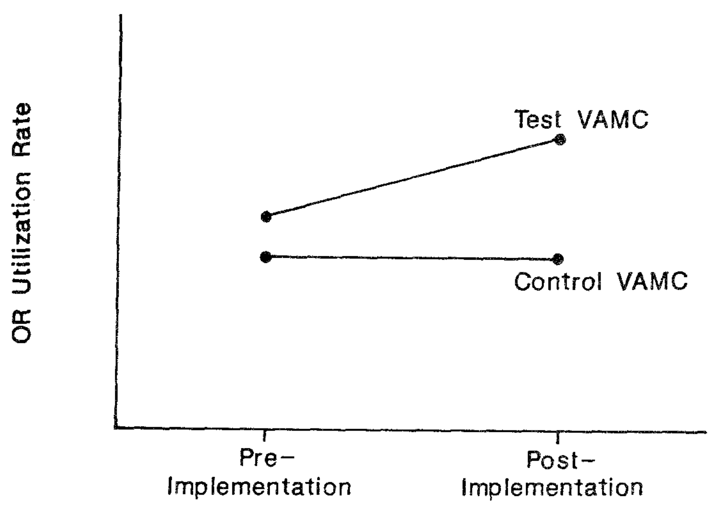

Figure 1. Hypothesized effect of scheduling system.

The hypothesis that implementation of a centralized, advance scheduling system is associated with an improvement in OR team utilization rate is tested by determining whether or not the regression coefficient β_3 of the interaction term is equal to zero. A conclusion that β_3 does not equal zero would support the research's hypothesis by indicating that there is an interaction effect between time period and medical center on OR team utilization rate, assuming that the nature of this interaction is in the desired direction.

The role of the β_3 coefficient in testing the research hypothesis can be illustrated further by substituting the appropriate values for the variables X_1 and X_2 into the regression equation (1), while holding the other terms in the equation constant:

$$(Y_{\text{test,post}} - Y_{\text{test,pre}}) - (Y_{\text{control,post}} - Y_{\text{control,pre}}) =$$

$$[\beta_1(1) + \beta_2(1) + \beta_3(1) - (\beta_1(0) + \beta_2(1) + \beta_3(0))] -$$
$$[\beta_1(1) + \beta_2(0) + \beta_3(0) - [\beta_1(0) + \beta_2(0) + \beta_3(0))] =$$

$$(\beta_1 + \beta_2 + \beta_3 - \beta_2) - (\beta_1) = \beta_3 \quad (2)$$

A positive, significant β_3 coefficient would indicate that the change in utilization at the test VAMC between pre- and postimplementation was significantly greater than the change in utilization at the control VAMC.

The dependent variable in the multiple regression model, log [utilization/(l-utilization)], is used instead of the actual utilization rate in order to increase the value of high utilization rates relative to low utilization rates. Once an OR's team utilization rate approaches the 80 to 85% level, there is very little the OR can do to increase the rate, because the unused 15 to 20% of available time is due primarily to factors beyond the OR's control. One such factor is the need to reserve sufficient time to accommodate emergency cases without causing significant disruptions to the scheduled cases. In order to achieve this objective, the amount of time that should be reserved is close to the maximum time required by emergency cases on any given day. On the average day, much of this time will not be used. Other factors contributing to unused time which are beyond the control of OR management include the last-minute cancellation of cases, and the completion of cases in less time than the amount originally reserved.

At lower utilization rates much of the unused time can be controlled by more aggressive management of the OR. Increases in OR team utilization are, therefore, easier to achieve at lower rates than at higher rates, and any observed increases at higher rates should be given more weight in the regression model.

RESULTS

Table 2 and Fig. 2 present the mean OR team utilization rates for the two VAMCs, pre- and postimplementation. As Fig. 2 depicts, the mean OR team utilization rate at the test VAMC rose 12 percent, from 0.688 prior to the implementation of the centralized scheduling system, to 0.771 postimplementation. The mean OR team utilization rate at the control VAMC fell 8%, from 0.781 during the preimplementation time period, to 0.726 during the postimplementation time period. A two-sample t test comparing the samples means of the test VAMC's preimplementation and postimplementation utilization

Table 2. OR Team Utilization Rates

	Preimplementation	Postimplementation
Test VAMC	0.688	0.771
Control VAMC	0.781	0.726

rates reveals a significant change in the utilization rates at the $p = 0.01$ level (actual $p = 0.00$). The change in utilization rates for the control VAMC is significant at the $p = 0.05$ level (actual $p = 0.03$). F tests of the two samples (pre- and post-) for each hospital support the hypothesis of equal population variances in both cases ($p = 0.75$ for the test VAMC and $p = 0.57$ for the control VAMC).

The results obtained from application of the multiple regression model are presented in Table 3. The F statistic for testing the hypothesis that all of the regression coefficients (except the constant term) are simultaneously zero is 13.47. Since the associated level of significance is 0.00, this hypothesis is rejected. That is, there is a regression relation between the dependent variable and the set of independent variables. The R^2 value of 0.299 indicates that the variance in the dependent variable is reduced by approximately 30% when the independent variables are included in the model.

The tests of each individual regression coefficient indicate that all but two of them are not equal to zero at $p = 0.05$. OR team utilization rate does not appear to be related to the number of cancellations or to the surgery bed occupancy rate. OR team utilization rate does seem, however, to be related to time period, medical center, the interaction of time period and medical center, procedure duration, number of overtime cases, and number of add-on cases. Table 4 presents the average values of each of the independent variables, pre- and postimplementation for each VAMC.

The coefficient of the interaction term is not equal to zero at the $p = 0.05$ level of significance (actual $p = 0.03$), indicating that OR team utilization rate is related to the

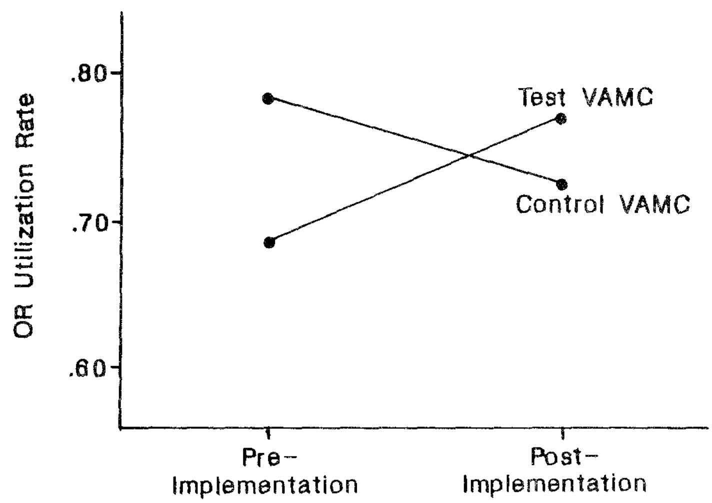

Figure 2. OR team utilization rates.

Table 3. Results of Regression Analysis

Dependent variable = $\log \frac{\text{utilization rate}}{1-\text{utilization rate}}$

$N = 262$ | F stat = 13.47 | Signif = 0.00 | $R^2 = 0.299$

Independent variable	Regression coefficient	T stat.	Signif.
Constant	−0.14713	0.56	0.58
Time period	−0.29986	−3.82	0.00
VAMC	−0.28943	−3.33	0.00
Interaction (time and VAMC)	0.25936	2.24	0.03
Procedure duration	0.00202	2.75	0.01
No. of overtime cases	0.19272	5.96	0.00
No. of cancellations	−0.02933	−1.51	0.13
Surgery occupancy	0.47429	1.43	0.15
No. of add-ons	0.07079	2.56	0.01

interaction of time period and medical center. Specifically, an increase in OR team utilization rate is associated with the test VAMC following implementation of the centralized scheduling system, while a decrease in utilization rate is associated with the control VAMC for the same time period. This relationship between utilization rate and the interaction of time period and medical center is significant while controlling for other variables which might affect utilization rate. Thus, the results support the hypothesis that the implementation of the centralized, advance scheduling system is associated with an improvement in OR team utilization rate.

An examination of the significance of the regression coefficients of the other independent variables reveals some interesting relationships between these variables and the dependent variable. The independent variable whose coefficient has the greatest signifcance is the number of overtime cases ($p = 0.00$). The result is not surprising, given that overtime cases prevent rooms from experiencing large gaps of unused time between the last scheduled case of the day and the end of scheduled hours. The positive regression coefficient supports this premise (i.e., an increase in the number of overtime cases is associated with an increase in utilization rate).

Procedure duration and number of add-on cases also have a positive, significant relationship to utilization rate ($p = 0.01$ for both variables). The positive relationship between number of add-on cases and utilization rate was expected. However, as noted in

Table 4. Values of Independent Variables

Independent variable (= avg/day)	Test VAMC		Control VAMC	
	Pre	Post	Pre	Post
Procedure duration (min)	1798	2130	1523	1714
No. of overtime cases	0.8	1.5	0.9	0.9
No. of cancellations	2.3	3.5	1.5	1.1
Surgery occupancy	0.77	0.87	0.69	0.73
No. of add-ons	1.3	1.8	0.8	0.8

the "Research Design" section, the relationship between procedure duration and utilization rate depends somewhat on the scheduling practices of the individual hospital. Because the results show a positive relationship between procedure duration and utilization, the hospitals are apparently able to schedule their cases to leave little unused time following the completion of longer cases.

The absence of a relationship between number of cancellations and utilization rate could be because the hospitals were able to fill up vacated time through the use of add-ons. Alternatively, to the extent that cases are cancelled because preceding cases ran past regularly scheduled hours, utilization would not be affected by cancellations.

The absence of a relationship between bed occupancy and utilization could result if OR capacity was a constraining resource (i.e., utilization of the OR does not increase during periods of high occupancy because there is insufficient capacity to accommodate the increased demand). Another possible explanation is that bed occupancy rate is not a good measure of the demand for OR time. Not all patients in surgery beds require surgery. Further, beds containing patients with long postoperative lengths of stay may not generate demand for surgery at the same rate as beds containing patients with short postoperative lengths of stay. A better measure of demand for surgery might have been the number of visits to the outpatient surgery clinics at the hospitals during the study periods, since it is from these visits that the need for surgery is usually determined. However, these data were not available.

It is not completely clear why the OR team utilization rate at the control VAMC decreased over the study time period. One possible explanation lies in the fact that the Surgery Service experienced some problems with surgeon staffing during the postimplementation time period. Although nurse staffing in the OR should have been adjusted to accommodate decreases in workload resulting from the reduction in surgeon staffing, it is possible that the adjustments were imprecise. Furthermore, the lack of a centralized scheduling system would have contributed to the OR's inability to adjust its staffing levels—an unfilled schedule could not be identified until the day prior to scheduled surgery, thus giving the OR little time to schedule additional cases or to adjust staffing. Other than the change in surgeon staffing, the control VAMC reported no other major organizational changes.

DISCUSSION

The research results indicate that implementation of a centralized, advance scheduling system can contribute to increased surgical suite utilization rates, by enabling more aggressive management of the use of OR time. Furthermore, the cost of implementing the scheduling system described here is relatively small—being essentially the cost of hiring an OR scheduling coordinator.

In order to realize tangible benefits from the implementation of the scheduling system, the resultant, improved utilization of the surgical suite should equate to an improvement in team productivity, where productivity can be measured in two possible ways: (1) the number of cases per team, or (2) the number of case minutes per team. As the complexity of surgical cases increases, along with their duration, the latter measure of productivity is generally preferred by OR managers. The increase in productivity should

Table 5. Team Productivity[a]

Productivity measure (= avg/day)	Test VAMC			Control VAMC		
	Pre	Post	Signif	Pre	Post	Signif
Scheduled cases/team	1.7	1.7	0.77	1.7	1.6	0.35
Add-on cases/team	0.2	0.3	0.06	0.2	0.2	0.17
Scheduled min/team	271	300	0.02	318	302	0.26
Add-on min/team	36	54	0.00	44	31	0.18
Case-length (min)	158	176	0.00	193	196	0.68

[a] The number of teams per day at the test VAMC increased from an average of 5.6 preimplementation to an average of 6.0 postimplementation. At the control VAMC this number increased from 4.2 to 5.1.

occur for the scheduled cases, rather than for the unscheduled (add-on) cases, if the increase is to be attributed to the advance scheduling system.

A review of the data for the test VAMC (see Table 5) reveals that the average number of scheduled cases per team per day stayed the same—at 1.7—from preimplementation to postimplementation. The average number of add-on cases increased slightly, from 0.2 to 0.3 per team per day.

An examination of the number of scheduled minutes per team per day reveals the reason for the improved utilization, despite the number of scheduled cases per team remaining the same. This figure increased approximately 30 minutes—from 271 to 300—which is statistically significant at the $p < 0.05$ level. This increase was due to a significant increase in the average case length—from 158 to 176 minutes. One can conclude, therefore, that the test VAMC was able to accommodate an increase in the complexity of its surgical case-mix (reflected in the longer average case length) without a corresponding increase in staff.

In addition to demonstrating the effectiveness of a particular scheduling system, this research demonstrates the utility of using a controlled experimental design in evaluating hospital scheduling systems. As discussed, no other formal evaluations of OR scheduling systems in actual hospital settings have been reported. Unfortunately, the same can also be said for the evaluation of hospital systems in general. Although the scheduling system evaluated in this research is not innovative, the approach for evaluating its implementation is. As hospitals look for ways of improving the utilization of costly resources, and as the costs of the improvements themselves increase, more efforts must be made to formally evaluate new or proposed systems. Hospitals can no longer afford to spend the time and effort to implement systems that have not been rigorously evaluated in terms of their effect on organizational efficiency and effectiveness.

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