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Predicting Patient Nonappearance for Surgery as a Scheduling Strategy to Optimize Operating Room Utilization in a Veterans' Administration Hospital

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Background: **Previous attempts at improving operating room utilization have generally emphasized more accurate scheduling, starting the first case on time, and reducing turnover time. Surgical case cancellations have largely been ignored except for recommendations for preoperative screening and good physician–patient communication to improve patient compliance.**

Methods: **A retrospective review of operating room records was initially used to identify reasons for surgical cancellations. This was followed by a retrospective stratified case–control study of patient records to identify preexisting factors that predict the failure of patients to appear for surgical procedures as scheduled. Factors assessed included demographics, type of surgical procedure, compliance with previous healthcare visits, substance abuse, mental illness, travel distance, and neurologic problems.**

Results: **The authors reviewed their operating room utilization and found patient nonappearance rates to be a substantial source of surgical cancellations. Furthermore, multivariate analysis demonstrated that patient nonappearance could be strongly predicted from patient noncompliance with clinic visits and other clinical procedures without reference to the other variables assessed. Further analysis of data from an independent sample of patients confirmed this observation.**

Conclusions: **Noncompliance with hospital visits for surgical procedures can be predicted from noncompliance with other healthcare encounters. Surgical procedures for previously noncompliant patients should be booked at the end of the operating room day, when the cancellation is least likely to interfere with operating room flow.**

OPERATING room (OR) utilization is increasingly important to hospitals in general, and within the Veterans Health Administration in particular. Although private sector medicine differs organizationally and financially from the Veterans Health Administration, both share the conundrum of increasing cost and decreasing reimbursement. Surgical downtime and overtime may be costly for ORs. Unproductive unscheduled downtime in the OR entails fixed cost not offset by net revenues (revenue minus variable cost). This net revenue is the opportunity cost of the downtime. This may be defined as the difference between lost revenues and the variable costs that would have been incurred if a procedure had actually been performed during that time. Furthermore, downtime during the day may require further unnecessary overtime to complete subsequent regularly scheduled cases in the evening. Furthermore, OR delays negatively affect staff and patient morale, and unnecessary evening overtime may interfere with OR availability for emergencies. OR utilization, defined as the ratio of OR time utilized to scheduled time available, can never be perfect.[1–3] However, we strive to maximize utilization to minimize downtime losses.

Some authors recommend improving OR utilization in the long term through better capacity planning, including OR block scheduling,[4] reallocation of time toward more profitable surgeons,[5] or process benchmarking (comparison to best practices).[6,7] Others emphasize shorter-term tactics focusing on timely first case starts, booking accuracy,[8] turnover time, and speeding surgical procedures themselves.[9] However, these have all been variably successful in improving utilization.[10–15] Indeed, superior utilization may not even be optimal, because too high an OR utilization inevitably results in delays for urgent cases, overtime, and even delays in elective cases scheduled too tightly, because the system is necessarily imperfect and chaotic.[3,16] For example, despite best efforts at standardization, it is simply not possible to predict which patients or staff will arrive late, which patients may have their cases cancelled for medical or other reasons, precisely how long a case will take to perform, or what unexpected problems may delay care or room turnover.

Unexpected OR cancellations are major causes of suboptimal OR utilization. OR cancellations are traditionally divided into avoidable cancellations (*e.g.*, scheduling errors, equipment shortages, cancellation due to inadequate preoperative evaluation) and unavoidable cancellations (*e.g.*, emergency case superseding the elective schedule, unexpected changes in the patient's medical status, or patient nonappearance). Preoperative anesthesia consultation clinics may reduce avoidable cancellations,[17] but such clinics require additional resources.

The focus on avoidable cancellations ignores unavoidable cancellations. However, a fundamental principle of modern management is to question whether unavoidable inefficiencies can be managed. We therefore examined the causes of unexpected OR cancellation over the

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past year at our hospital. The most common proved to be patients not coming for scheduled procedures, although our system clearly communicates OR scheduling information to patients at the time of booking by a dedicated clinic coordinator, reinforces this information at a subsequent visit for preadmission testing, and finally attempts to telephone the patient on the day before surgery.

We hypothesized that we might predict patient nonappearance on an objective basis from the preoperative record. Although it would not be appropriate to deny surgery to such patients, identifying such patients might permit even more vigorous attention to reinforcing the necessity of arriving at the OR as scheduled. Furthermore, we reasoned that if we could identify such patients in advance, they could be scheduled at the end of the OR day, when nonappearance would be less likely to disrupt the OR schedule and result in OR overtime.

Materials and Methods

Initial Operating Room Cancellation Review

Initial review of OR cancellations was performed using a surgical scheduling package. (The surgical scheduling system used at our institution, the John D. Dingell VA Medical Center, is distributed, maintained, and mandated by the United States Department of Veterans' Affairs, Washington, D.C.) OR cancellations are routinely recorded in this package on the day of surgery. For this purpose, we reviewed all cases from January 1, 2004, to March 1, 2005. To verify the representativeness of the overall cancellation rate and the rate of patient nonappearance for surgery during this period, we further assessed the rates of cancellation and patient nonappearance at weekly intervals over a 5-yr period from May 1, 2000, to May 1, 2005, and calculated 95% confidence intervals for these rates based on this information.

Patients

Twenty-seven consecutive patients who missed their surgical procedures unexpectedly in the first half of fiscal year 2005 were identified by review of the Veterans Health Administration surgical scheduling package, and their nonappearance status was confirmed by medical record review. For each such patient, three additional patients were randomly identified within the same time period that had been scheduled for surgery by the same surgical service but had actually undergone their scheduled surgical procedures. This selection was performed by two chance selections. An OR day was first chosen by chance, and then rejected if it was a weekend or holiday day when no elective cases had been scheduled or if the surgical service that had operated on the index patient had no scheduled cases. In such a case, another chance date selection was made. Then, a random selection was made from among the OR cases performed by that service on that day. All choices were made by an analyst blinded to demographic and other relevant information. Inpatients and patients undergoing emergency procedures were excluded from analysis. Therefore, the total patient pool studied included 108 patients.

Data Collection

For each such patient, the computerized medical record was reviewed. We recorded age, date of the planned operation, scheduling service, and home address. In addition, we recorded any indication within the medical record over the preceding 6 months of significant alcohol or other substance abuse, and any mental health or neurologic diagnosis or care that might impair cognitive function. (For example, a mild left-sided stroke was not recorded as a neurologic problem, but self-described generalized memory loss was so recorded.) Finally, taking advantage of the strength of the computerized medical record, we assessed each visit to the John D. Dingell VA Medical Center (Detroit, Michigan) that the patient had been scheduled to make over the year preceding his operation. We excluded emergency room or unscheduled visits, clinics or tests scheduled while an inpatient, clinic visits listed as "cancelled by clinic," and any other visits in which it was impossible to determine from the medical record whether the patient had actually received care. We then recorded how many total evaluable visits the patient had during that year and in how many of these visits the patient either had not come in for the visit or had cancelled his appointment. In cases in which a patient was scheduled for more than one visit on the same day, we considered the entire day as one visit. In some instances, a patient had received two appointments at essentially the same time and come to only one of them. In such cases, we recorded the patient as having come for his visit on that day and considered the second visit nonevaluable. By our criteria, approximately 70% of all recorded visits were scored as evaluable. Reasons for nonevaluable visits included cancellation by the clinic, more than one clinic visit on the same day, "visits" by inpatients, and visits to our urgent care center, which were excluded because they were thought to be different from routine clinic visits. Telephone clinic encounters were also excluded as nonevaluable.

We also separately recorded whether the patient had come for preadmission testing (PAT). In cases in which an initial PAT visit had apparently been missed but the patient then came in for PAT before surgery, we considered that the patient had undergone PAT. In our system, patients have historically at times been given PAT appointments at short notice and have had this information communicated to them by mail. This has posed difficulties for the patients, particularly if the patient received the mail close to or even after the date of the PAT appointment. If patients miss such appointments, either they contact the PAT office or the PAT office contacts them to reschedule the appointment. Because the PAT appointment process is unique in terms of the short lead time, mail appointments pose unique difficulties. Although we could have chosen to count each PAT appointment as a separate appointment, we chose instead to give patients credit for attending PAT if they came to any PAT appointment. Although either technique might have been informative, we believe that this technique has yielded important results that are more consistent with our actual practice patterns, because a missed PAT visit in this institution triggers a call to the patient to reschedule rather than a call to the surgeon.

Statistical Analysis

Data were analyzed using Sigma Stat 3.0 (SPSS, Inc., Chicago, IL). We began by comparing each recorded dependent variable between those patients who had their procedures and those who did not come to the hospital for them. This was done by Mann–Whitney rank sum test for continuous variables and Yates-corrected chi-square test for discontinuous variables. After this initial exploratory univariate analysis, we performed multiple logistic regression[18,19] on our data set, considering OR nonappearance as our dependent variable. After arriving at a demonstration that we could predict OR nonappearance with moderate success using our set of variables, we then conducted stepwise regression analyses to further identify the most significant independent variables.[18,19]

Decision Rule Assessment

Having evaluated our data and derived potential decision rules, we identified an additional convenience sample consisting of all patients who had been scheduled to undergo surgery on 3 additional days outside the study period, choosing at random days in which one patient had not appeared for a scheduled procedure. We again excluded inpatients, emergencies, and patients whose procedures had been cancelled preoperatively for administrative reasons. An additional 29 patients were identified in this manner, whose records were similarly reviewed, and used to assess the accuracy of potential decision rules. After performing this analysis, we identified a third patient population, consisting of 450 consecutive patients who either underwent surgical procedures or were cancelled for nonappearance in the months of March or April 2005, and similarly reviewed their records and reassessed the accuracy of the chosen decision rule in this data set. Accuracy of each decision rule was calculated as the ratio of the sum of correct predictions of appearance and nonappearance by that decision rule among all patients in the study population to the total number of patients in each study population.

Table 1. Surgical Case Cancellations, October 1, 2004, to March 20, 2005

Cancellation Reason	Number	% of Cases	% of Cancelled Cases
Patient nonappearance	83	5.5	30.1
Medical	74	4.9	26.8
Patient/guardian refuses	42	2.8	15.2
Administrative	24	1.6	8.7
Scheduling error	24	1.6	8.7
Emergency case supersedes	12	0.8	4.3
Patient ate or drank	9	0.6	3.3
Previous case duration	3	0.2	1.1
Anesthesia	1	0.1	0.4
Consult not done	1	0.1	0.4
Intensive care unit bed	1	0.1	0.4
Laboratory test	1	0.1	0.4
Operating room	1	0.1	0.4
Total	276	18.3	100.0

Results

Reasons for OR Cancellations

Medical record review confirmed that all patients listed as having had their surgery cancelled had in fact not had surgery, whereas all patients listed as having undergone surgery in the surgical scheduling package did in fact undergo such procedures, thus generally validating the use of the surgical package to identify OR cancellations and reasons thereof. Review of OR cancellations from October 1, 2004, to March 20, 2005, demonstrated an OR cancellation rate of 18.3%. Several reasons for these cancellations were listed (table 1), of which the most common were patient nonappearance and changes in medical status. Patient nonappearance accounted for 30.1% of OR cancellations during this period and 5.5% of all scheduled OR cases during this period. Interestingly, if one were to add patient nonappearance rates to those for patient/guardian refusal, and patient noncompliance with requirements to abstain from food or water by mouth, one calculates that 48.6% of OR cancellations during this period may have involved patient compliance issues. Approximately 8.7% of OR cancellations were coded as “administrative.” Historically, these generally represent either case overruns from previous case duration or scheduling errors.

Historically, although cancellations themselves were recorded correctly, the reasons for cancellation have not always been recorded accurately within our institution. Although the failure of patients to appear for scheduled surgery was relatively easy for staff to determine, other causes of cancellation, such as medical reasons, surgeon preference, scheduling errors, and administrative issues, were not always as easy to distinguish. The accurate ascertainment and recording of cancellation reasons has been emphasized at our institution since the beginning of the 2004 fiscal year, which is why we had restricted our detailed analysis of cancellation reasons to this interval. However, we then reviewed 5 yr of data, from May

Table 2. Comparison of Nonappearing and Appearing Patient Samples

	Nonappearing Patients	Appearing Patients	*P* Value
Missed PAT	75%	0%	< 0.001
No. of missed clinic visits/patient	9.48 ± 1.52	3.78 ± 0.42	< 0.001
Total clinic visits/patient	26.19 ± 3.38	25.40 ± 3.50	NS
Age, yr	59.52 ± 2.55	61.11 ± 1.36	NS
Alcoholism	25.90%	9.88%	< 0.08
Other substance abuse	18.50%	4.94%	< 0.07
Travel distance/patient, mi	48.56 ± 37.14	37.15 ± 6.89	NS
% Clinic nonappearance	35.42 ± 3.48	15.55 ± 1.38	< 0.001
Any substance abuse	33.33%	13.58%	< 0.05
Significant psychiatric issues	33.33%	12.34%	< 0.03
Significant central nervous system impairment	7.40%	2%	NS
Psychiatric or central nervous system impairment	40.70%	15.00%	0.01

NS = not statistically significant; PAT = preadmission testing.

1, 2000, to May 1, 2005, divided into weekly intervals, for overall cancellation rates and patient nonappearance rates, to assess the likelihood that our sample might represent the overall experience at our institution. Indeed, this substantially larger time interval included 14,828 scheduled procedures. The overall cancellation rate during these 5 yr was 19.73% (95% confidence interval, 18.96–20.50%), and the patient nonappearance rate was 5.24% (95% confidence interval, 4.79–5.69%).

Comparisons between Nonappearing and Appearing Patients for Surgery

For more intensive review of individual cases, we focused on more recent cases because of an increasing emphasis on accuracy of coding of clinical workload in the institution over the past year. We chose 27 consecutive cases of patient nonappearance for more detailed analysis and matched them with 81 randomly chosen cases in which patients had undergone surgical procedures over the time period and by the same surgical services. This provided a total of 108 evaluable patients. Demographic and other characteristics of these patients are shown in table 2, with data presented as mean ± SE.

Univariate analysis suggested statistically significant differences in rates of missing preadmission testing, missing clinic visits, rates of substance abuse, and severe mental health or psychiatric issues between these two groups of patients. We further examined the positive predictive value of each of these independent variables in a univariate fashion using logistic regression and recorded the likelihood ratio test statistic for each independent variable. These results are represented in table 3. Correlations with failure to come for preadmission testing, percent nonappearance in clinic, and number of nonappearance visits seemed particularly strong. Data mining procedures are potentially powerful tools for analyzing OR procedures. We tested Classification and Regression Tree Technology (CART) on our data set, using Cart for Windows (Salford Systems, San Diego, CA). Cart analysis yielded similar results to the logistic regression.

Multivariate Analysis

We next performed a logarithmic regression, using OR nonappearance as the dependent variable to be predicted. This multivariate analysis produced a model that utilized most of the independent variables, including failure to come for preadmission testing, the number of clinic visits missed, the number of clinic visits scheduled, and the percentage of clinic visits missed. (Historically at our institution, patients who have been scheduled for a clinic visit and missed it are rebooked for a second clinic visit, so that patients who miss clinic visits would tend to have more clinic visits scheduled than those who come to all scheduled appointments.) In addition, age, travel distance, alcohol and substance abuse, and psychiatric issues were used by this initial multivariate model. The overall regression model exhibited a likelihood ratio test statistic of 90.105 (-2 * Log-(Likelihood) = 30.781; $P < 0.001$)

Striking among our observations was the apparent high predictive value of a patient not arriving for his preadmission testing appointment, because all of the patients who came for surgery also came for preadmission testing, but only 25% of patients who did not come for surgery in our data set came for their preadmission testing. However, since preadmission testing at our institution typically occurs after the date and time for a

Table 3. Univariate Logistic Regression

	Univariate
Missed preadmission testing	$P < 0.001$
No. of missed clinic visits	$P < 0.001$
Total clinic visits	NS
Age, yr	NS
Alcoholism	$P < 0.05$
Other substance abuse	$P < 0.04$
Travel distance, mi	NS
% Clinic nonappearance	$P < 0.001$
Any substance abuse	$P < 0.03$
Significant psychiatric issues	$P < 0.02$
Significant central nervous system impairment	NS
Psychiatric or central nervous system impairment	$P < 0.01$

NS = not statistically significant.

surgical procedure have already been selected, we reasoned that consideration of the failure to come for preadmission testing would be less useful in initially scheduling surgical procedures than consideration of variables known at the time when the procedure was scheduled. Repeating the logarithmic regression after eliminating PAT nonappearance as a variable yielded a model that still had substantial power, with a likelihood ratio test statistic of 37.080 (−2* Log(Likelihood) = 83.806; $P < 0.001$)

We therefore performed forward step regression analyses on our data without including the PAT variable. In such forward analysis, the independent variable with the strongest predictive value is incorporated first into the model, and then other variables are checked to determine whether they add anything into the model. In this analysis, percent clinic nonappearance proved the strongest individual predictor, and the model could not be improved significantly by adding any other variables. The model using percent clinic nonappearance as the sole independent variable exhibited a likelihood ratio test statistic of 30.161 (−2 * Log(Likelihood) = 91.303; $P < 0.001$). The R^2 value for this model was only 0.278 (adjusted R^2 = 0.271), suggesting that other factors extrinsic to our data set also contribute to determining whether a patient will come to the OR as scheduled. We explored this correlation further by examining the distribution of patients who came and did not come for surgery. A box plot of the distribution of the percent nonappearance variable among patients who came or did not come for surgery as scheduled also suggested that patients who missed clinic appointments frequently tended to also miss their OR procedure appointment (not shown).

We therefore pursued this further by dividing the patients in our data set into quintiles based on their percent clinic nonappearance rate and then calculating OR nonappearance rates for each quintile. Because our stratification strategy had set the appearance/nonappearance ratio in our data set to be 3:1, whereas the actual nonappearance rate in our institution approximates 5.5%, we multiplied the nonappearance and appearance rates in our data set by the ratio of the relative proportions of these in actual practice to the proportions in our data set to predict appearance rates in each percent nonappearance quintile for our actual population of patients. Thus, figure 1 represents the predicted rates of compliance and noncompliance with OR scheduled procedures based on patients' rates of compliance with clinic visits. Although some patients came for surgery in each of the lowest three quintiles, our model predicted steadily increasing odds that patients in the higher quintiles would not come for scheduled surgery. In particular, for patients with less than a 20% clinic nonappearance rate, our model predicted that the probability of a procedural nonappearance was 1.76%, whereas for patients exceeding a 20% nonappearance rate, the predicted probability

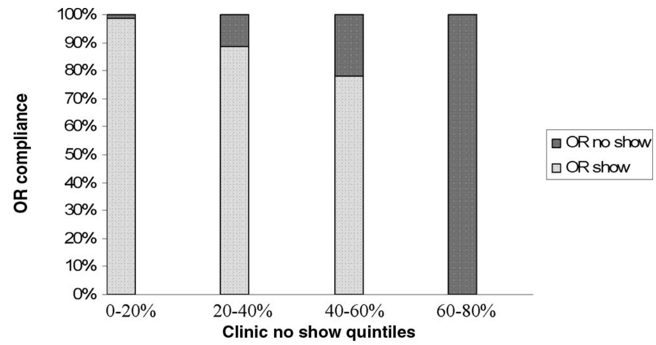

Fig. 1. Stacked bar chart represents the relative proportions of patients coming for surgical procedures in the operating room (OR) as scheduled (OR show) to patients missing scheduled surgical procedures (OR no show) among patients classified in each of the lowest four quintiles by their rates of nonappearance (no-show) behavior in outpatient hospital clinics. The proportion of OR nonappearance behavior increases dramatically in the higher quintiles. There were no patients in the data set classified in the highest quintile (> 80% clinic nonappearance rate), so this bar has been omitted.

of a procedural nonappearance was 15.6%. For patients exceeding a 40% nonappearance rate, the predicted probability of a procedural nonappearance was 33.6%, whereas virtual certainty of a procedural nonappearance was predicted for patients exceeding a 60% nonappearance rate. No patient was observed with a nonappearance rate in excess of 80%.

Having evaluated our data without the PAT variable, we then returned to this variable. PAT nonappearance strongly predicted subsequent procedure nonappearance, although many patients who came for preadmission testing also missed their scheduled procedures. Stepwise regression analysis suggested that PAT information significantly improved the predictive power of a model based on percent nonappearance alone, increasing the likelihood ratio test statistic to 81.528 (−2 * Log(Likelihood) = 39.936; $P < 0.001$) and increasing the adjusted R^2 from 0.271 (with percent nonappearance alone) to 0.699 (with both percent nonappearance and PAT compliance as independent variables). Indeed, no patients in our data set who missed PAT came to the OR as scheduled, although 7 of the 88 patients who came to PAT (8%) still missed their OR procedure appointment. Therefore, knowing whether a patient complied with PAT seemed to offer substantial additional predictive power beyond that provided by the predictive power of the percent clinic nonappearance variable alone. These 7 patients were distributed through the second and third quintiles for the percent clinic nonappearance variable.

Comparison with a Second Data Set

We recorded information about an additional 29 patients scheduled for outpatient procedures after the termination of the initial study period. Three did not appear for surgery, and 26 came for surgery as scheduled. For the 3 nonappearance patients, the outpatient clinic nonappearance rate was 50.4 ± 5.1%, whereas for the 26 compliant patients, the outpatient clinic nonappearance rate was 12.6 ± 2.4%. These again differed significantly ($P < 0.001$). For this small randomly selected independent data set, the decision rule to predict OR nonappearance for all patients above the first quintile in outpatient clinic nonappearance rates would have yielded 79.3% accuracy, incorrectly predicting OR nonappearance behavior for 6 patients in the second quintile for outpatient clinic nonappearance. The decision rule to predict OR nonappearance for all patients above the second quintile in outpatient clinic nonappearance rates would have been 96.6% accurate, incorrectly predicting that 1 patient in the second quintile would come for surgery as scheduled who actually failed to do so.

Comparison with a Third Data Set

Encouraged by this preliminary validation, we next examined a consecutive series of 450 patients scheduled for outpatient or same day surgery over March or April 2005. Four hundred twenty patients came to the hospital on the day of surgery and underwent a procedure as scheduled, and 30 patients in this data set did not come for surgery as scheduled. For the 30 nonappearance patients, the outpatient clinic nonappearance rate was 28.5 ± 3.4%, whereas for the 26 compliant patients, the outpatient clinic nonappearance rate was 18.5 ± 0.7%. These also differed significantly ($P < 0.001$). For this data set, the decision rule to predict OR nonappearance for all patients above the first quintile in outpatient clinic nonappearance rates would have yielded 63.1% accuracy. However, the decision rule to predict OR nonappearance for all patients above the second quintile in outpatient clinic nonappearance rates would have been 92.9% accurate.

Assessment of Impact of Cancellation due to Patient Nonappearance on Operating Room Utilization

To demonstrate that patient nonappearance adversely impacts OR utilization, we assessed the utilization of OR use over 4 months for all rooms in which an elective case had been cancelled for because a patient had not come to the hospital for scheduled surgery. Forty-one such room-days were identified. Because utilization might vary with the day of the week or the service scheduling into that room, we compared these utilization data with the utilization of OR use for the same room on the same day of the week for the week before and the week after the day in question. Holidays or other days in which a room was deliberately underbooked were excluded from analysis. Our standard OR day is scheduled for 7.5 h/day. For rooms in which a cancellation occurred because of patient nonappearance, we found that there were 5 ± 0.27 unused hours in the OR day. However, for the weeks before or after a cancellation, the same OR on the same week day was found to have 3.6 ± 0.32 or 3.6 ± 0.29 h of unused time. These data were normally distributed, and a paired t test demonstrated the differences between unused hours on days characterized by cancellations and on parallel days 1 week before or after cancellation to be statistically significant ($P < 0.001$ for each). An extra 1.4 h of unused OR time corresponds to a 19% decrease in OR utilization for that room.

To estimate the cost of running an OR, we used the John D. Dingell VA Medical Center's implementation of Decision Support System software (a modified version of commercial software from Eclipsys Corporation, Boca Raton, FL). We took the total cost for the month of September 2005 of the OR on the financial side of Decision Support Software and the cost portion of anesthesia that we could determine to be OR work and then divided by the work hours for the month. A similar result was obtained by taking the total unit cost of the individual products in the OR department and anesthesia products for the OR and using the relative value unit minutes determined an average hourly cost. We deducted from these figures the costs of medications, supplies, or treatments actually applied to patients in the OR, because these would not be required if an OR was empty. We added back to the resulting figure the cost of an hour of a surgical resident's salary, which comes out of a separate budget and is not included in the Decision Support Software allocation, because surgical residents serve as first assistants in our hospital. These analyses yielded an hourly rate of approximately $555. Although such analysis requires many assumptions that could readily be second guessed, the analysis does suggest that the average 1.4 h OR downtime associated with an OR cancellation at our hospital may be associated with approximately $775 of costs that are not offset by corresponding revenue or workload.

Discussion

Our institution previously set 20% as the allowable surgical procedure cancellation rate, emphasizing more traditional measures to improve OR utilization, such as attempting to ensure timeliness of first case starts and accuracy of OR booking. However, a 20% cancellation rate substantially impairs OR utilization. In particular, even among cancellations, our hospital, like many, has divided cancellations into avoidable and unavoidable, choosing the former for special scrutiny but relegating patient nonappearance to the latter category. However, the most common or substantial causes of suboptimal OR utilization should receive the most attention, and our surgical procedure nonappearance rate represents approximately one third of all cancellations and more than 5% of all scheduled cases. Our observations suggest that it may be possible to predict with relative ease and moderate reliability which patients are likely to miss their scheduled surgical procedures at the time these patients are evaluated and scheduled from within the surgical clinic. Such predictions may facilitate strategies to better manage the impact of patient noncompliance on OR utilization.

It may be objected that our nonappearance rate is higher than that at some other institutions. Hand *et al.*[20] reviewed the causes of OR cancellations in 1990 and found that most reflected either administrative problems such as lack of consent or inadequate preoperative medical evaluation, suggesting greater attention to each of these issues. In contrast, Lacqua and Evans[21] found that inadequate preoperative medical evaluation and patient nonappearance were the most common causes of OR cancellation in a different data set but emphasized improved physician–patient communication to minimize the nonappearance rate. Certainly many private hospitals may have lower nonappearance rates, but this likely depends to a large extent on the patient population as well as the effectiveness of patient education. We would expect, for example, that large inner city hospitals might have higher nonappearance rates by virtue of the patient population they serve. For our particular institution, for example, approximately 10% of our patients are homeless, and their lack of resources may certainly impede their compliance with scheduled medical care.

Our observations suggest that patients who frequently miss clinic appointments are likely to miss their surgical procedure appointment. Macharia *et al.*[22] have previously described the use of clinic nonappearance rates as an indication of patient noncompliance and suggested improved communication, telephone follow-up, and physician–patient contracts as ways to improve patient compliance with future clinic visits. Basu *et al.*[23] similarly emphasized mail and telephone communication as a way to improve attendance for outpatient minor surgery. However, we already have procedures by which OR dates and times are confirmed with the patient in person before booking and reconfirmed at preadmission testing (if the patient comes for preadmission testing). Patients who miss their preadmission testing appointment are routinely called by the PAT staff to be rescheduled. Finally, OR times are reconfirmed again by a personal phone call on the night before surgery (if the patient has a telephone number by which he or a family member or friend can be reached). Despite these strategies, our nonappearance rate remains high. Physician–patient contracts seem more suited to outpatient care with its repetitive visits than isolated surgical procedures.

The management of nonappearance rates represents a standard problem for many commercial enterprises, such as hotels and airlines. These have generally adopted a strategy of compensatory overbooking, often using sophisticated computer models to predict nonappearance rates and balancing the cost of empty seats or rooms against the cost of compensating an overbooked customer who cannot be accommodated.[24–26] Although ethical considerations may prohibit turning patients away from medical care, most clinics and doctors' offices adopt similar strategies, except that they are less aggressive in overbooking, instead asking overbooked patients to wait longer to be seen, and balancing patient dissatisfaction with wait times, staff overtime if required, and physician dissatisfaction with overwork against the opportunity cost of an empty clinic or an idle office. Such strategies would seem less acceptable in an OR environment, however, because the costs of overrunning the elective schedule are much more substantial. Furthermore, another surgeon and patient may be scheduled to follow a series of overbooked cases, or the surgeon who is overbooked may have commitments elsewhere.

Like many hospitals, our institution uses a block scheduling system, in which surgeons schedule their patients in blocks. Because we typically run four to six ORs, depending on the day and the schedule, the hospital does not have many patients waiting for other OR time who can be moved ahead in the schedule to fill holes caused by cancellations. Our administrative staff is alert for opportunities to fill such holes with emergency procedures if time for an emergency procedure happens to have been requested, and if a surgeon of the relevant specialty is available and not operating in a different block at that time. However, more often than not, this is not possible. The administration does make every effort to move up patients within an OR block on that day, if they arrive sufficiently early, and to call patients scheduled for later in the day to see if they can come in earlier to fill such unexpected vacancies in the schedule. Many of our patients travel long distances to come to the hospital or are dependent on others for their travel arrangements, so most patients cannot simply come immediately when called. Therefore, such efforts have been only partially successful but likely explain why patient nonappearance is associated with a mean increase in OR unused time of only 1.4 h.

Our current observations raise the possibility of prediction of patient nonappearance for surgery by their history of clinic nonappearance and management of the impact of such noncompliance by better scheduling. Therefore, we have used our observations to propose that patients who have missed more than 40% of their previous clinic appointments over the past year should be booked only as the last case of the day. The confirmation of the accuracy of this basic decision rule in our independent samples lends further weight to this proposal. Furthermore, if a scheduled patient misses his preadmission testing appointment, we have asked that this be communicated back to the OR and the clinical service booking the case, so that this patient's OR time can be moved to the end of the day if this is still possible. In addition, for services booking relatively short procedures into the OR schedule, such as upper endoscopies or minor plastics procedures, identification of patients at a very high likelihood of noncompliance with the OR schedule (such as those whose noncompliance with clinic visits exceeds 60%) may justify permitting more traditional overbooking.

Although the correlation between clinic visit noncompliance and surgical procedure visit noncompliance is statistically highly significant, the relatively low R^2 value suggests that other factors not present in our data set have strong predictive value. This is not surprising, considering the complexity of factors that determine whether a patient comes for a surgical procedure. Moreover, the current observations represent correlation but not causation. We doubt that if it were possible to ensure that a given patient came to clinic or preadmission testing, this would make it much more likely that he would then come for his operation. Failure to come for a scheduled operation does not seem to be a function of distance traveled but is likely to reflect a complex interaction between personality, belief structure, support system, and attitudes toward self, hospital, and medical care. For example, patient satisfaction with medical decision making influences subsequent patient compliance.[27] The suggestion of a weaker correlation between substance abuse and procedure noncompliance may be either causal or a marker for such psychological issues. Nevertheless, the simple correlation between clinic noncompliance and procedure noncompliance does offer a relatively simple and potentially useful way to make some prediction about whether a patient is likely to appear for a scheduled surgical procedure.

Furthermore, it should be emphasized that correlative analysis of this sort in no way represents an attempt to "blame the patient." Indeed, many of patients labeled as high risk for not coming will actually arrive for their surgical procedure. However, because being scheduled for a later surgical procedure is not stigmatizing and should result in minimal inconvenience, we do not believe that such categorization needs to be foolproof. Certainly, if greater confidence were desired, one could set the cutoff higher at the risk of having more unexpected cancellations during the OR day rather than at the end of the day.

A limitation of this study is that it does not describe the actual results of comprehensive implementation of such a strategy. We are currently in the process of arranging for automatic calculation of each patient's annual clinic cancellation and nonappearance rate within our electronic medical record, which should facilitate such implementation.

Observations such as these are likely to be institution specific and vary with patient flow patterns and the characteristics of the patient population served. For instance, the rate of patient nonappearance may be higher at our institution than at some other hospitals. For example, Schofield *et al.*[28] described an approximately 2.3% patient-driven cancellation rate for elective procedures on working weekdays on the day of intended surgery. We took advantage of this high rate of nonappearance to investigate whether and how patient nonappearance for surgery might be predicted in advance. It would clearly be important to validate these results in any other institution before simply adopting our suggested predictive rule, because results in other hospitals may vary. Institutions servicing private practices not based in the hospital itself might need to partner with the office managers of such private practices to access rates of patient noncompliance with scheduled office visits outside the hospital. Therefore, application of this concept must be individualized for each facility. Nevertheless, it seems likely that the general principle that patient nonappearance for surgery may be predicted by nonappearance for other healthcare encounters can be usefully generalized to many other facilities and would require relatively little implementation cost.

Similarly, in some profitable hospital systems, it may be more cost-effective to consistently finish late than to consistently finish early and have to pay staff to not work. This is likely less true in the Veterans Health Administration system, in which patient care has less direct effect on revenue. Nevertheless, it is clearly better to finish on time than to finish late. If the OR is scheduled so as to consistently finish late when all patients arrive as scheduled, we believe it would be desirable to have patients who do not come to the hospital for their appointments scheduled at the end of the day, so that the OR that usually runs late could now finish on time. We therefore propose here a method to predict patient nonappearance and to schedule such patients so that if they do not arrive for scheduled surgery, the OR will be less likely to finish late.

Although we believe that the strategy we propose for identifying and managing high risk OR bookings may be applicable to other healthcare systems, the data must be individualized for each institution, because differences in patient population, nonappearance rate, geographic and other barriers to care may vary among institutions. The utility of correlation with clinic nonappearance rates will also depend on whether this information can be readily captured in other systems. A strength of the Veterans Health Administration system in this regard is that all healthcare events within the system are captured within the electronic medical record, with scheduled visits and patient nonappearance or cancellations clearly indicated on the face page of the record in an easily accessible fashion. Some private-sector health maintenance organization systems may have similar ready access to the records of a large number of patient interactions for such analysis. Hospitals that rely on outside referral patterns or do not capture all their interactions within a single reliable record may have more difficulty implementing this approach but may find that other variables within their own system may also have predictive power.

Incontrovertibly, strong efforts should be directed at improving patient communication and facilitating patient compliance with scheduled procedures. Such efforts are not only medically and ethically appropriate, but also, to a certain extent, cost-effective because noncompliant patients must be rebooked at the cost of further resources. However, at a certain point, directing further resources to achieving compliance may no longer be cost-effective or reasonable. Our current observations suggest that even if a high patient nonappearance rate is unavoidable, strategies may be devised for reducing the impact of this nonappearance rate on OR utilization. The relative simplicity of the "book high-risk-for-cancellation patients last" strategy we propose here may compare favorably with the technical difficulty of various sophisticated computer techniques that have been proposed to facilitate OR resource allocation.[4,29–31] Furthermore, we speculate that some medical cancellations, such as patients eating after midnight or failing to comply with preoperative regimens, and some patient refusals of surgery may have similar predictability from the same variables, as may some delays due to patients not arriving on time. This remains a subject for future investigation.

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