The Effect of the Operating Room Coordinator's Risk Appreciation on Operating Room Efficiency

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BACKGROUND: The Operating Room Coordinator (ORC) is responsible for filling gaps in every operating room (OR) schedule. We have observed differences among the personalities of the four ORCs with regard to their willingness to agree to assume more risk concerning their daily planning. The hypothesis to be tested is that the relationship between the personality of each of the four ORCs and the risk an ORC is willing to take of cases running late affects OR efficiency.

METHODS: In order to judge the personality of an ORC in relation to risk-taking in planning schedules, we applied the Zuckerman-Kuhlman Personality Questionnaire in our study. Seven anesthesiologists were asked to score every ORC on willingness to take risks in planning. To analyze which risk attitude creates more OR efficiency, the daily prognosis of the ORC compared with the actual OR program outcome was registered during a 5-mo period in 2006 and 2007. We analyzed whether, in the opinion of hospital management, the costs of reserving too much OR time balances with the costs of reserving too little OR time, and whether this result is consistent with the assignment of the management tasks of the ORC.

RESULTS: Seven anesthesiologists classified the four ORCs into the risk-averse group ($n = 2$) and the nonrisk-averse group ($n = 2$). The Zuckerman-Kuhlman Personality Questionnaire results for risk-seeking indicate that there is a difference in risk appreciation among the different ORCs. The main finding in our study is that the nonrisk-averse ORC plans to fill the gaps in more cases in the OR program than the risk-averse ORC does. The number of extra cases performed by the nonrisk-averse ORC as compared to a risk-averse ORC is 188 in 2006 and 174 in 2007.

The average end-of-program-time per OR/day for the nonrisk-averse ORC is 34 min (±19 min, $P = 0.0085$) later than for the risk-averse ORC. We find that this hospital on average reserves more OR time for procedures than is actually required. The nonrisk-averse ORC takes more advantage of that extra OR time than the risk-averse ORC does by scheduling extra cases during office hours. The success of the nonrisk-averse ORC can be linked to the fact that there is usually time available due to this over-reserving.

CONCLUSIONS: The conclusion of this study is that a nonrisk-averse ORC creates significantly less unused OR capacity without a great chance of running ORs after regular working hours or canceling elective cases scheduled for surgery compared to a risk-averse ORC.

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Changes in the financing of the Dutch health care system have forced health organizations to focus more on the efficiency of their logistic processes. The operational risk of operating rooms (ORs) is mainly related to elective surgical cases being completed outside regular working hours. A possible consequence of this extension past regular hours is that surgeons anticipate the availability of this extra OR time in their future planning. Having to often work beyond regularly scheduled hours can lead to both overtime costs and intangible costs, the latter resulting from dissatisfaction and reduced motivation on the part of the staff. Having to often work overtime in the ORs is one of the primary reasons[1] that nurses terminate their employment. Identified scheduling conflicts are a major cause of nursing staff turnover.[2]

The OR is also an important financial production unit. The hospital management determines the OR capacity and assigns capacity to the different medical specialties. Increases in the efficiency of use of the ORs results in more production and therefore more revenue for the hospital.

The Operating Room Coordinator (ORC) is a nurse anesthetist, selected for this specific job in this specific hospital. In our hospital there are four ORCs. Their responsibilities include rearranging case and staff

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assignments, as some OR cases take more or less time than originally planned, and unplanned acute patients require surgery. Their jobs involve frequent communication with the various stakeholders, such as anesthesiologists, surgeons, and other OR staff. The responsibilities of the ORC in our study relate to the regularly scheduled work hours of 8 AM to 4 PM.

Given the fixed OR capacity between 8 AM and 4 PM, the ORC is assigned by hospital management to maximize OR efficiency by filling the gaps with as many cases as possible (planned and unplanned) under the constraint that ORs should close, on average, no later than 4 PM. Minimization of OR inefficiency balances the additional costs of cases running late (i.e., overtime has to be paid out and staff morale dwindles) against the opportunity costs of paying idle staff.[3] From an economic point of view, an ORC is constantly weighing the maximization of OR efficiency against minimizing reduced staff morale.

As more cases are performed within the maximum margins of the available OR time without often overstepping those boundaries, maximum efficiency will eventually increase, and therefore so will the contribution margin for the hospital.

Every extra case performed in the OR provides a certain amount of Contribution Margin that goes toward the covering of fixed costs. The Total Contribution Margin is Total Revenue (TR) minus Total Variable Cost (TVC): Total Contribution Margin = TR−TVC.

It is interesting to understand how the ORC balances OR idle time with exceeding the scheduled time, given these constraints.

One of the characteristics of the Dutch health care system is its strong supply-side controls (hospital, government). Since 2005, there has been a rapid transition to a demand-driven (patient) model, resulting in increased competition among the hospitals. Additionally, the Dutch social system is founded on balancing work and private time, all in favor of private time. Today, on average, the ORs are open for business from 8 AM to 4 PM. Because of the impending transition to a demand-driven model, this will lead to a need for hospital management to make different choices (i.e., open hours). Longer open hours will not decrease the need for an existing ORC, since this very same ORC will have the task of filling gaps and maximizing OR efficiency.

We have observed differences among the personalities of the four ORCs, related to their willingness to take on more risk in their daily planning, resulting in a risk of cases running late. This was our motivation for analyzing the effect of personality and risk aversity of an ORC on OR efficiency.

The hypothesis to be tested was that the relationship between the personality of the ORC and the risk the ORC is willing to accept of cases running late affects OR efficiency. Specifically, we hypothesize that a risk-averse ORC causes more inefficiency for the OR.

The Saint Franciscus Hospital in Rotterdam (The Netherlands) is an average-sized general hospital (613 beds) with 8 ORs. In recent years, the number of operations that have taken place have increased sharply. The result of this increase is a rising shortage of available OR capacity. However, due to the implementation of a number of logistical concepts in the OR in the past 2 yr, improvements in efficiency have made a further increase in OR production possible. These logistical concepts were closely studied during and after implementation. One of these concepts is the role of the ORC and the influence of his/her character on the decision-making process concerning the efficiency of the OR. We performed a prospective study on this concept.

METHODS

A decision-maker is said to be risk-averse if he prefers less risk to more risk, all else being equal. In the OR, a risk-averse decision-maker will want all the ORs to be finished before 4 PM without any chance of running late. The opposite of risk aversion is risk-seeking. A risk-seeking decision-maker will prefer more risk to less risk, and accepts the possibility of running late, all else being equal.

There are numerous contributions to the conceptualization of subjective orientation toward risk.[4–6] Some studies analyze the interaction between personality feature variables which are not risk attitudes. These variables have been linked to decision-making on risky courses of action,[7] impulsiveness[8] and decision-making style.[9]

Zuckerman[10,11] developed the Zuckerman-Kuhlman Personality Questionnaire (ZKPQ) to assess personality along five dimensions. The results of the ZKPQ have been replicated across several studies. These results have shown, for example, that risk-taking is related to scores on the ZKPQ impulsive sensation seeking scale.[10] Zuckerman[7,11,12] defines sensation-seeking as a need for new and complex experiences and a willingness to take risk for one's own account. He has found that high sensation-seekers tend to anticipate lower risk than low sensation-seekers do, even for new activities. This finding indicates that a high sensation-seeker is more likely to look for opportunities that provide the chance to take a risk, and that the will to take risks seems less threatening to this specific type of individual.

To assess personality versus the risk-taking relationship of an ORC, we applied the ZKPQ in our study. The personal files of the ORCs indicated that their personalities were assessed by the ZKPQ test along five dimensions: Impulsive sensation-seeking, neuroticism-anxiety, aggression-hostility, activity, and sociability. This test was a standard procedure during the selection process of the ORCs. We used the scores of the impulsive sensation-seeking dimension and used the explanatory table (Zuckerman) to rate the ORCs. In our study, we grouped ZKPQ scores on

impulsive sensation-seeking as follows: the scores of very low and low were considered to be risk-averse, the average scores were considered risk-neutral, and the high and very high scores were considered to be nonrisk-averse.

Before the start of the study, seven anesthesiologists where asked to score every ORC on their risk appreciation. This risk appreciation could be: nonrisk-averse, risk-averse or risk-neutral. In 2006, before the start of the study, the ORCs were informed about this study, whereas in 2007 they were not.

In order to analyze which risk attitude creates maximum OR efficiency, the ORC's expectations with regard to how the OR program would materialize was registered during a 5-mo period in 2006 and 2007. This expectation, or prognosis, is proposed by the ORC and he informs the anesthesiologist on duty of this. When making the prognosis, the following aspects are estimated and noted by the ORC:

- Which OR(s) need(s) time after business hours;
- Which OR(s) are on schedule;
- The amount of available OR capacity for emergency surgery during the period from 2 PM until 4 PM. This capacity is designated for patients already on the waiting list and for emergency patients outside or inside the hospital who may possibly need emergency/acute surgery;
- The number of the planned elective patients that are to be rejected.

If at 4 PM, all the above-mentioned aspects have been accurately estimated, we say that the ORC's prognosis has materialized. In all other cases, the prognosis has not materialized.

During the study period, we measured:

1. Whether the prognosis of the ORC made at 2 PM coincides with the actual situation at 4 PM (% of all prognoses made)
2. Accurate prognosis made at 2 PM that specific ORs would need extra time after regular working hours (% of all prognoses made)
3. The average end time of all ORs
4. The average end time of all ORs after 4 PM
5. The average number of ORs in progress after 4 PM
6. The number of unnecessary rejections of planned elective patients

We tested for significance in the average end of program time among individual ORCs, and within the groups having a factorial analysis of variance (significance level 0.05).

The correlation between cases is considered to be independent but interchangeable between ORs.

As in Tessler et al.'s study,[13] we analyzed whether, in our hospital, limited hours serve to restrain the budget. This will help us to understand whether it is cost-effective for the OR management to proceed with a surgical case rather than to postpone it.

Olivares and Terwiesch[14] makes an estimation of cost variables based on observed system behavior and assumed rational behavior in reserving OR time for an individual cardiac procedure. Based on Olivares and Terwiesch's analysis, we analyzed whether, in the opinion of hospital management, the costs of over-reserving a procedure are lower or higher than the costs of under-reserving a procedure, and whether this result is consistent with the assignment of the management tasks of the ORC. This result gives us insight into whether Olivares and Terwiesch's analyses can be generalized to more than one procedure.

In this study, no bias was present from seasonal influences or from various new specialized procedures. This study focused on one of the many issues related to imperfect utilization of ORs. We quantified them and measured the effect of management decisions aimed at reducing imperfection.

Due to fixed OR capacity in our hospital, the short-term objective in maximizing OR efficiency is to reduce under-utilized OR time,[15] because there are regular cancellations of patients due to medical reasons in the 24-h period prior to surgery.

In order to calculate the inefficiency related to the level of risk aversity, we used the following definition.[16] OR inefficiency is the sum of under-utilized OR time and over-utilized OR time, multiplied by the relative costs of overtime. Under-utilized time is hours of staffed operating time at straight time wages, but not used for surgery, set-up or clean-up of the OR. Over-utilized time is hours after OR time, staffed at overtime.

After finishing the first study, the ORC were asked to continue to register their prognosis of the progress of the OR program at 2 PM and actual outcome at 4 PM.

The following data were excluded in order to compare the results: unexpected complications during an elective case after 2 PM (2006 $n = 2$, resp 2007 $n = 1$), disruption of the elective program due to a patient who was brought in with an aneurysm (2007, $n = 1$). Data were summarized using mean ± SD.

RESULTS

The seven anesthesiologists, anonymously and independently of each other, classified two ORCs in the category of risk-averse, and two in the category of nonrisk-averse ($n = 2$). Risk indifference was not scored. The results of the ZKPQ are shown in Table 1. The expectations of the anesthesiologists, as well as the results of the ZKPQ tests, all indicate in the same direction, i.e., that there is a difference in risk appreciation among the ORCs.

Table 2 shows the quantitative results of the two groups.

Nonrisk-averse group: In 87% of the cases, actual outcome at 4 PM matches the prognosis given at 2 PM over the two periods.

In 84% of the cases, the expectation that the ORs would finish after working hours matched actual

outcome. On average, the end-time of the ORs is 3:50 PM (±12 min). The average end-times of ORs after 4:00 PM are 4:19 PM (±17min). The average percentage of ORs in progress after 4:00 PM is 12.6% (2.5%). The number of unnecessarily rejected planned elective patients in the study period of 5 mo is 2 in 2006 and 3 in 2007.

Risk-averse group: In 22% of the cases, actual outcome matches the prognosis over the two periods. In 48% of the cases, the expectation that the ORs would finish after working hours matched actual outcome. On average, the end-time of the ORs is at 3:16 PM (±18 min). The average end-time of elective ORs after 4:00 PM is 4:17 (±17 min). The average percentage of ORs in progress after 4:00 PM is 10.1% (3.1%). The number of unnecessarily rejected planned elective patients in the study period of 5 mo is 7 in 2006 and 6 in 2005.

The difference in end-time between the two ORC groups (risk-averse and nonrisk-averse) is 34 min (±19 min) per OR per day ($P = 0.0085$).

Table 1. Zuckerman-Kuhlman Personality Questionnaire—Scores of the Impulsive, Sensation-Seeking Dimension

ZKPQ score per ORC	
ORC	ZKPQ score (%)
#1	81
#2	92
#3	25
#4	32

00%–27% very low impulsive, sensation-seeking.[11]
28%–41% low impulsive, sensation-seeking.
42%–70% average impulsive, sensation-seeking.
71%–84% high impulsive, sensation-seeking.
85%–100% very high impulsive, sensation-seeking.
ORC = operating room coordinator; ZKPQ = Zuckerman-Kuhlman Personality Questionnaire.

Within these groups, we encountered some differences: The average time between the two risk-averse ORCs does not differ significantly ($P = 0.291$). The average end-time of the two nonrisk-averse ORCs is significant ($P = 0.034$). The comparison of the ZKPQ results between the ORCs within the nonrisk-averse group does not explain these differences. We can only conclude that within the risk-averse group, the two are each others' equivalent. Within the nonrisk-averse group, one ORC showed significantly better results than the other.

The number of extra cases performed by the nonrisk-averse ORC compared to a risk-averse ORC is 188 in 2006 and 174 in 2007. We can calculate the extra contribution margin for the hospital if, for example, in 2007, 174 more total hip replacements were performed (the patients for this surgery were actually available on a waiting list). The estimated TR for 174 cases is $2.1 million. The estimated TVC is $0.9 million. This results in an extra contribution margin of $1.2 million/yr. The contribution margin ratio is equal to $(2.1-0.9/2.1) \times 100\% = 57\%$.

We analyzed ex-post how many cases the risk-averse group and nonrisk-averse group could have planned in the time period from 2:00 PM–4:00 PM. For this analysis, we specifically used either the average time or the median of the case duration, whichever value was larger. For the risk-averse group, the numbers were 133 (2006) and 127 (2007). For the nonrisk-averse group, the results were 12 and 15. As mentioned before, these cases were actually available for filling gaps in the programs.

The distribution of working days per ORC (Table 3) is uniformly distributed. The OR schedule is shown in Table 4. We analyzed the demand for OR time during the historical period in time, and the study period.

Table 2. Main Results Per Type Operating Room Coordinator (ORC) Per Study Period

	Nonrisk-averse		Risk-averse	
	2006	2007	2006	2007
Working days	98	102	98	102
The prognosis of the ORC made at 2 PM matches the actual outcome at 4 PM (% of all prognoses made)	86%	88%	44%	53%
Accurate prognosis made at 2 PM that specific ORs will require extra time after regular working hours (% of all prognoses made)	86%	82%	18%	26%
The average end time of all ORs	3.53 PM (±8 min)	3.46 PM (±10 min)	3.13 PM (±15 min)	3.19 PM (±12 min)
The average end time of all ORs still running after 4 PM	4.20 PM (±18 min)	4.18 PM (±14 min)	4.16 PM (±17 min)	4.19 PM (±17min)
The average number of ORs in progress after 4 PM	13.8% (±2.5)	11.3% (±2.5)	8.8 (±1.3)	11.3% (±3.8)
The number of unnecessary rejections of planned elective patients (period of 5 mo)	2	3	7	6

OR = operating room; ORC = operating room coordinator.

There were no significant differences in the planned end-time of the various OR suites (Table 5).

Furthermore, we studied the sample variance among OR-day combinations.

For the study period, we used Levene's test of homogeneity of variances. With $P = 0.903$ (2007) and $P = 0.189$ (2006), we conclude that in both study periods we can accept the null hypotheses of equal variances. We performed the one-way analysis of variance to compare means of case duration of the four ORCs. With a P value of 0.603, we accept the null hypotheses of equal means for case duration for the four ORCs.

Finally, we conducted the factorial analysis with procedure time as the dependent variable, and "specialty" and "day" as fixed factors. Because we have a fixed OR schedule, we see that "day" and "specialty," and their interaction with each other are significant ($P < 0.001$).

We also affirm in our study that a risk-averse person orders less than the normative benchmark and that a risk-seeking decision-maker orders more than that very same normative benchmark.[17]

We calculated the mean inefficiency per OR per day by considering each OR-day to be independent of all others. The relative cost of overtime in our study is 1.50. The cost per hour of over-utilized OR time includes: indirect costs, intangible costs and retention and recruitment costs incurred on a long-term basis from staff working late. The mean inefficiency per OR per day for the risk-averse ORC is 0.87 (±0.29), n = 1,600. For the nonrisk-averse ORC, the mean inefficiency per OR per day is 0.46 (±0.20), n = 1,600. This means that the nonrisk-averse ORC causes less OR inefficiency.

In 65.9% of all cases, the procedure was completed in as much time or less time than had been reserved by the OR. In 34.1% of all cases, more time was needed than was reserved. Comparing these results leads to the conclusion that case durations are over-estimated. The over-reserving leads to idle time. The nonrisk-averse ORC takes more advantage of this over-reserving than the risk-averse ORC does, by scheduling extra cases during hours.

The OR management assumes that from the cost perspective it is better to finish in ORs during regular hours. Therefore we performed Tessler et al.'s study[13] in our hospital (Table 6) to verify this assumption. As concluded by Tessler et al., we confirm that it is cost-effective to proceed with a surgery case after regular working hours rather than to postpone the case. This outcome helps OR management to further improve OR efficiency.

DISCUSSION

In recent years, market forces have made their entry into the health care system in the Netherlands. As a result, the government and insurance companies increasingly wish to scrutinize the added value of care

Table 3. Distribution of Working Days of Operating Room Coordinators (ORCs)

	Nonrisk-averse ORC		Risk-averse ORC	
	#1	#2	#3	#4
2006				
Monday	9	10	10	10
Tuesday	10	10	10	10
Wednesday	10	10	9	10
Thursday	10	10	10	10
Friday	10	9	10	9
Total	49	49	49	49
2007				
Monday	10	10	10	11
Tuesday	10	11	10	10
Wednesday	10	10	10	10
Thursday	10	10	11	10
Friday	10	11	10	10
Total	50	52	51	51
Tot	99	101	100	100

ORC = operating room coordinator.

Table 5. Average Planned End Time Operating Room (OR) Suites

OR	Historical	Study period
1	3:25 PM ± (21 min)	3:21 PM ± (23 min)
2	3:22 PM ± (32 min)	3:19 PM ± (29 min)
3	3:35 PM ± (29 min)	3:28 PM ± (26 min)
4	3:35 PM ± (18 min)	3:29 PM ± (20 min)
5	3:21 PM ± (27 min)	3:22 PM ± (25 min)
6	3:47 PM ± (17 min)	3:45 PM ± (19 min)
7	3:59 PM ± (14 min)	3:58 PM ± (15 min)
8	3:17 PM ± (34 min)	3:19 PM ± (36 min)

In the period 2005–2007, we studied the average planned OR time and compared this with the average planned OR time during the study period.

The average planned OR time is the sum of the planned OR time of all cases for a specific OR, including a standard turnover time of 11 minutes between cases divided by the number of days.

OR = operating room.

Table 4. OR Schedule

	1	2	3	4	5	6	7	8
Monday	Orto	Orto	Neuro	Gen	Sur	Plast		
Tuesday	Orto	Orto	ENT		Gen Sur	Gen Sur	Gyn	Eye
Wednesday	Orto	Orto	Gen Sur	Jaw	Plast	Uro	Gen Sur	Gen Sur
Thursday	Orto	Orto	Gen Sur	Gen Sur	Plast	Neuro	Uro	Eye
Friday	Orto	Orto	Gen Sur	Gen Sur	Plast	Gyn	Gen Sur	Gen Sur

For example: operating room (OR) suite 1 is assigned to Orthopedic surgery every Monday.

ENT = ear nose and throat; OR = operating room.

Table 6. Zero Tolerance for Overtime Increases Surgical Per Case Costs

Average hourly wages for Saint Franciscus Hospital including benefits labor costs per hour (in dollars)	
Postanesthesia care unit nurse	35.02
Operating room nurse	40.85
Surgical ward nurse	29.18
Anesthesia technician	43.00
Administration	35.02
Public relations, purchasing	
Telecommunications, garbage disposal	
Accounting, human resources	
Laundry/housekeeping	17.51
Maintenance	19.84
Security	23.34
Pharmacy	37.35
Radiology	32.68
Laboratory	32.68
Central supply room	15.17
Physiotherapy	36.77
OR labor costs hourly	450
Marginal tax rates	
Income ($)	Tax rate (%)
0–26,844	15.75
26,844–48,239	23.50
48,239–82,249	42.00
82,249 and higher	52.00

Costs calculated in the society pays model (after tax values) in dollars

	Proceed with case	Postpone case
OR labor costs		
1.5 h standard cost	377.58	
1.5 h overtime cost	566.37	
3 h standard cost		755.16
Anesthesia technician costs		
1.5 h standard cost	38.06	
1.5 h overtime cost	57.08	
3 h standard cost		76.11
OR supplies costs	292.95	292.95
Anesthesia supplies costs	39.00	39.00
Professional fees	310.25	310.25
Hospital costs per surgical bed/day		
Labor	219.55	439.10
Supplies	17.06	34.12
Hospital costs per patient bed/day		
Administrative	8.75	17.51
Technical		
Laundry/housekeeping	2.92	5.84
Maintenance	1.65	3.31
Security	4.67	9.34
Pharmacy	9.71	19.42
Radiology	19.61	39.22
Laboratory	14.71	29.41
Central supply	5.31	10.62
Physiotherapy	5.15	10.29
Postanesthesia care unit		
Labor	109.25	218.49
Supplies	7.34	14.68
Lost income for one day (after tax)		0.00
Professional fees saved		310.25
Total	2106.96	2635.06

Costs calculated in the patient pays model in dollar

	Proceed with case	Postpone case
OR labor costs		
3 h standard cost	1348.50	1348.50
Anesthesia technician costs		
3 h standard cost	199.95	199.95
OR supplies costs	292.95	292.95
Anesthesia supplies costs	39.00	39.00
Professional fees	646.35	646.35
Hospital costs per surgical bed/day		
Labor	399.18	798.36
Supplies	17.06	34.12
Hospital costs per patient bed/day		
Administrative	13.89	13.89
Technical		0.00
Laundry/housekeeping	4.49	4.49
Maintenance	2.71	2.71
Security	7.07	7.07
Pharmacy	16.46	16.46
Radiology	33.23	33.23
Laboratory	24.51	24.51
Central supply room	7.93	7.93
Physiotherapy	8.58	8.58
Postanesthesia care unit		0.00
Labor	182.08	182.08
Supplies	7.34	7.34
Lost income for one day (after tax)		0.00
Total	3251.28	3667.52

Assumptions as in Tessler et al.[13], calculated for our hospital.

Marginal tax rates for individuals were derived from the Ministry of Finance. The marginal tax rate varies between 15.75 % and 52% depending on annual income.

OR = operating room.

processes. Dealing with efficiency plays an important role in this evaluation. The more efficiently the processes can be organized, the more efficiently the various resources can be used.

Many extensive studies on OR efficiency[18–23] can be found in the literature. All these studies contribute to optimizing the use of scarce and costly ORs, especially in private hospitals in a competitive environment. The effect of the type of risk appreciation of an ORC in relation to OR efficiency has not been described in the literature.

The results of our study are in compliance with the findings in the literature we used: a high sensation seeker is likely to look for opportunities that provide the chance to take a risk, and this risk will seem less threatening to this kind of individual. Though there is much evidence to support the link between personality and risk-taking, the literature shows that the exact nature of these is still unclear. The next step is to discover what happens in the mind of a risk-taker that is significantly different from what occurs in the mind of a nonrisk-taker.

Based on Olivares and Terwiesch's preliminary analyses, we concluded that, in the opinion of our hospital management, the cost of over-reserving a procedure is 48% lower than the cost of under-reserving. From that perspective, we could conclude

that frequently, the OR management prefers to reserve more time than actually needed, hence the conclusion that our hospital often prefers to be finished earlier rather than late. From an economic point of view, this is irrational behavior because the opportunity costs of idle OR time are considered to be lower than for utilized OR time. Hence, the conclusion of Olivares and Terwiesch's based on specific cardiac surgery cases cannot be generalized to a situation in which there is a heterogeneous mix of different operations and patients. When we mathematically conclude that an OR over-reserves, this fact does not mean that the OR management often prefers to reserve more time than actually needed. The fact is that, for whatever reason, on average, this hospital over-reserves.

On average, properly scheduled ORs will finish early two-thirds of the time and late one-third of the time.[24] In our hospital, that proportion is in accordance with these results.

Although the data from this study are statistically strong, there are some specific potential drawbacks. The first factor is that the study population (four ORCs) is relatively small. Despite being able to attain statistically significant data, it will be important to follow the trends as ORCs are introduced in the OR system.

The second factor is our decision to choose one axis: sensation seeking. But there are other axes, such as neuroticism-anxiety, aggression-hostility, activity and sociability that can be either important, necessary or completely determinative for an ORC's success in planning the schedule. This has to be analyzed in future studies with a larger population of ORCs.

The third factor is the number of ORs. In our study, we observed eight ORs. The effect of the difference on OR efficiency may be influenced by the number of ORs. Since two additional new ORs have been built, we recommend performing this study with 10 ORs rather than 8, to examine the effect of a bigger span of control for the ORC on OR efficiency.

The ORC works in an environment of over-reserving. Hence, the question arises whether the ORC will also be successful in the case of under-reserving. Risk aversity is a typically human attitude toward risk. In the case of under-reserving, the nonrisk-averse person will always explore the extremes of all the possibilities available. In such cases, this trait can lead to dissatisfaction among the OR staff, because the chance of having to work overtime structurally increases in combination with the risk that planned cases will be canceled. This effect leads to material and immaterial damage for both patients and hospital. In such a case, it is quite easy to imagine that a risk-averse ORC will be more successful in his tasks at hand. This should be studied further in another setting.

One could take the point of view that even with accurate planning or deliberate over-booking, it would be best to have the nonrisk-averse ORC employed, because over-utilized time can be justified due to the fact that more cases will get done. The hospital then simply must take the strategic steps to bring the case volume up to the planned capacity of the OR suite, by adding rooms, expanding hours, etc. However, in the short-term, a nonrisk-averse ORC who schedules cases into an already overbooked OR will create significant animosity among the staff.

CONCLUSION

The conclusion of this study is that a nonrisk-averse ORC creates significantly less unused OR capacity without a great chance of running ORs after regular working hours or canceling elective cases. Added to this, a nonrisk-averse ORC is cost-effective. This means that when recruiting an ORC, the risk-averse type must be one of the selection criteria. These findings will help management to further optimize OR efficiency, and the results can be used in further research into a decision-support system to provide recommendations.

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