Typical Savings from Each Minute Reduction in Tardy First Case of the Day Starts

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BACKGROUND: Analysts and clinicians sitting in operating room (OR) committee meetings cannot evaluate rapidly whether a suggested idea to reduce delays in first case of the day starts can be beneficial economically.

METHODS: Three years of data were used from a six OR outpatient surgery facility. The cost reduction from reducing the tardiness of start of first cases of the day was calculated using the method of McIntosh et al. (Anesth Analg 2006;103:1499–516), limited to ORs with at least 8 h of cases and turnovers. Results were then reported per minute reduction in tardy first case of the day starts as an approximation for rapid use in meetings.

RESULTS: Each 1.0 min reduction in the tardy starts of first cases of the day in ORs with more than 8 h of cases and turnovers resulted overall in 1.1 ± 0.1 min reduction in regularly scheduled labor costs (mean ± SE). This result was close to the 1.2 min obtained using an entirely different (simulation) method performed previously for OR time reductions. Secondary analyses confirmed that assumptions were satisfied at the facility, thereby reducing the chance that results are biased. For example, the proportions of the variance in tardiness attributable to anesthesiologists and specialties were only 1% and 3%, respectively, and there were no significant differences in tardiness among the 85 anesthesiologists or 14 specialties.

CONCLUSIONS: Typical savings for reducing tardiness of first case of the day starts at a surgical suite equal the product of four values: i) 1.1 min reduction in staffed OR time per 1 min reduction in tardiness, ii) estimate for reductions in tardiness (min) per OR, iii) number of ORs at the suite with more than 8 h of cases, and iv) sum of the average compensations per regularly scheduled minute for personnel in each OR. If small, the analyst and/or clinician can promptly speak up and refocus group conversation toward other potential interventions. If large, the full return on investment analysis would be performed.

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Tardy first case of the day starts is a common topic of discussion by operating room (OR) committees.[1] In our companion paper, we show that a lack of knowledge of scientific principles related to increasing OR efficiency and a psychological bias that most cases start later than scheduled contribute to organizational focus on first case of the day starts.[2] A consequence of the lack of knowledge and presence of bias is that groups designed to enhance consensus among leadership stakeholders can become fixated on strategies[3–7] to avoid small delays in time that are not economically important. If an analyst or knowledgeable clinician participating in the meetings had a screening method to evaluate rapidly (e.g., in 5 min) the potential benefit of ideas to decrease such delays, proposals with no likely return could be dismissed without the need for a full analysis. No such screening methods are currently available, resulting in a requirement to complete a time-consuming analysis for all proposals, or, even worse, implementation without an understanding of the economic impact.

Consider the evaluation of whether hiring more nurses and transporters[8,9] at a daily average cost of $1000 would result in a net savings or cost if there were a reduction in the frequency of tardy first case of the day starts from 25% to 10%. The answer is generally not obvious for several reasons. First, the stated goal does not capture the amount of time saved. Second, reductions in the frequency of tardy starts can result in an *increase* in overall tardiness if focus is placed on the wrong ORs.[10] Third, there are very few

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facilities for which each 1.0 min reduction in OR time results in a 1.0 min reduction in OR labor costs, because rarely are all OR personnel part-time workers, paid hourly, and paid only for the hours worked.[11,12] For the vast majority of facilities, most staff are paid or contracted for at least 8 h on each day worked. Thus, OR labor costs are generally stepped costs (i.e., neither purely fixed nor variable),[11–15] complicating managerial accounting for OR time.[16]

McIntosh et al.[13] showed in their Table 7 how to perform cost accounting for reductions in the tardiness of first case of the day starts while incorporating differences in workload and staffing among specialties and days of the week. They showed that there is no answer to the question: "What is the total cost per minute of tardiness in the start of first cases of the day?" However, they did review a valid process to calculate the return on investment (ROI) of a proposed changed that would reduce the tardiness. Unfortunately, the process relies on computer software, extraction of data from an OR or anesthesia information management system, and approximately half an hour of an experienced analysts' time. Thus, the ROI calculation cannot practically be done on a notepad by someone who is sitting in a meeting.

For reductions in both intraoperative and turnover times, not only are full methods of analysis available,[13,17] but also corresponding methods to screen for potential benefits.[12]

> Example #1: A facility has one OR for each specialty, cases are scheduled into 8 h workdays, cases are not moved among ORs, each 1 h of over-utilized OR time costs 1.50 times each 1 h of regularly scheduled time, mean OR times are 1.48 h, and mean reductions in time are 4.2 min per case (see below). Then, from row 5 of Table 3 in Dexter et al.,[12] each 1 min reduction in OR time would result in approximately 1.2 min of labor cost savings for each OR with more than 8 h of cases, and 0 min for the ORs with fewer than 8 h of cases.

In this example, the analyst estimates the savings by multiplying together four numbers: i) 1.2 min reduction in staffed OR time per 1 min reduction in OR time, ii) the estimate for the reduction in OR time (min) per OR, iii) number of ORs with more than 8 h of cases and turnovers per day, and iv) sum of the average compensations per regularly scheduled minute* for personnel in each OR. If that calculation shows potential for the intervention to be cost saving or cost neutral, the full method of analysis from McIntosh et al.[13] would be applied. In this study, we obtain a similar estimate for typical savings achievable from reducing tardiness of first case of the day starts, as can be used for rapid assessment such as in meetings.

METHODS

Of the four components in the corresponding equation for the typical savings from improving first case of the day starts, the one value that needs to be estimated is the number of minutes of staffed OR time saved per 1 min reduction in the tardiness of the first cases of the day. The Appendix lists the steps to estimate this value using data from the studied facility. The Methods gives the steps we used to confirm that the data used were suitable for the calculation.

We studied all 20,437 cases performed at the six OR outpatient surgery facility of a hospital from July 1, 2004, to December 31, 2007. No case was performed on a holiday or weekend. The OR times averaged 1.48 ± 0.01 h per case. We report data as mean ± SE.

We rely on the following definitions:

OR workload for a specialty on a day refers to its total hours of OR and turnover times on the day.[13] Because no urgent cases were performed at the facility, *turnover time* was calculated simply as the time from when a patient exited the OR until the next patient entered the same OR on the same day.[18]

Under-utilized OR time = (allocated OR time) − (OR workload) if the difference was positive, and 0 h if the difference was negative.[13,19] The allocated OR time was the hours of specialty-specific OR time into which the cases were effectively scheduled.

Over-utilized OR time = (OR workload) − (allocated OR time) if the difference was positive, and 0 h if the difference was negative.[13,19] Under-utilized OR time and over-utilized OR time were calculated for each combination of specialty and day.[13]

OR labor cost = (allocated OR time) + 1.50 × (over-utilized OR time), where the value of 1.50 is described above. The value is in units of time, and can be converted to units of currency as shown in the footnote* and legend of Table 1. Reductions in OR labor costs are estimated as in the last paragraph of the Introduction.

Inefficiency of use of OR time = (under-utilized OR time) + 1.50 × (over-utilized OR time).[13,19]

In order to study the typical effect of reducing the tardiness of first case of the day starts, we needed a facility with three characteristics: official end of regularly scheduled hours that matches that based on minimizing the inefficiency of use of OR time, large mean tardiness of first case starts, and homogeneity in tardiness of first case starts among anesthesiologists and specialties. We consider each of these three in sequence.

The policy of the facility we studied was that cases were scheduled into ORs only if they were expected to

*For example, annual compensation may be $32,000 for a surgical technologist, $50,000 annually for a registered nurse, and $320,000 for an anesthesiologist. The amount to use would be $3.35 per min, where $3.35 = ($32,000 + $50,000 + $320,000)/(8 h × 250 workdays × 60 min/h).

Table 1. Daily Reduction in Labor Cost from Reducing Tardiness of Starts of First Cases of the Day (Normalized to Labor Cost of $1 per Regularly Scheduled Minute)

		Reduction in tardiness (min)							
		1	2	3	4	5	6	7	8
ORs with >8 hr of Cases and Turnovers	1	1.1	2.2	3.3	4.4	5.5	6.6	7.7	8.8
	2	2.2	4.4	6.6	8.8	11.0	13.2	15.4	17.6
	3	3.3	6.6	9.9	13.2	16.5	19.8	23.1	26.4
	4	4.4	8.8	13.2	17.6	22.0	26.4	30.8	35.2
	5	5.5	11.0	16.5	22.0	27.5	33.0	38.5	44.0
	6	6.6	13.2	19.8	26.4	33.0	39.6	46.2	52.8
	7	7.7	15.4	23.1	30.8	38.5	46.2	53.9	61.6
	8	8.8	17.6	26.4	35.2	44.0	52.8	61.6	70.4
	9	9.9	19.8	29.7	39.6	49.5	59.4	69.3	79.2
	10	11.0	22.0	33.0	44.0	55.0	66.0	77.0	88.0

To determine the potential cost reducing by reducing tardiness of starts of first cases of the day, select the cell corresponding to the typical number of operating rooms (ORs) with more than 8 h of cases and turnovers and the anticipated reduction in tardiness. Multiply the value in the cell by the actual staffing cost at your facility in $/min. For example, at the studied facility, there were two ORs running more than 8 h each day and a proposed reduction in tardiness of 3 min. Therefore, the value in the cell would be 6.6. Based on an OR labor cost of $3.35 per regularly scheduled minute of OR time as calculated in the footnote,* the daily savings for the surgical suite would be approximately $22.11, where $22.11 = 6.6 × $3.35. If the savings is sufficiently large that intervention may be implemented, the full method of analysis (see Appendix) would be performed.

OR = operating room.

end by 3:30 PM. We checked that 3:30 PM was the actual, effective end of allocated OR time, because otherwise the facility would not have been suitable for study. We did this by determining the percentage of cases finishing after 3:30 PM and comparing that percentage to the value that should be observed if OR time had been allocated based on minimizing the inefficiency of use of OR time. Suppose that each 1.0 h of over-utilized OR time cost the same as 2.0 h of regularly scheduled (under-utilized) OR time. In other words, it was twice as expensive to finish late as finish early.[13] Then, as proved by Strum et al.,[20] the inefficiency of use of OR time would be minimized by scheduling the cases so that ⅔rd of the ORs finished before 3:30 PM and ⅓rd finished late.[13,19] For a relative cost of 1.0 h of over-utilized OR time to regularly scheduled time of 1.50 (i.e., the amount paid to hourly workers for overtime), 60% of ORs should finish by 3:30 PM,[13,19] where 60% = 100%/(1 + 1/1.50). We calculated the percentages of the 4983 combinations of workday and OR ending by 3:30 PM and compared the observed percentages to check that it was between 60% and 66%.

The objective of our study was to quantify the typical cost savings from reducing the tardiness of start of first cases of the day. Tardiness is quantified by taking the difference between the actual and scheduled room entry time, and setting the value equal to 0 if the case enters the OR early. For example, if a case is scheduled to start at 7:15 AM, and the patient enters the OR at 7:20 AM, the tardiness is 5 min. If the patient enters the OR at 7:14 AM, there are 0 min of tardiness. Although we report the percentages of ORs starting 5, 10, and 15 min late for comparison to other papers,[21] the percentages are not used for analysis,[5,22] because reporting of the percentages (as compared to tardiness) can result in undesirable consequences. Reports on first case of the day starts do change clinicians' behavior,[3,6,23] and anesthesiologists do reduce their personal percentages of ORs starting late.[6] Resulting interventions on the day of surgery to reduce the percentages of OR starting late can increase average tardiness, increase over-utilized OR time, and increase labor costs.[10] The reason is that optimal decisions to reduce percentages of late first case starts can result in disproportionate little attention to ORs that have met the threshold for being late.[10,24] In contrast, decisions based on reducing average tardiness weight all ORs equally, resulting both in on-time starts and the desired operational benefits from achieving those on-time starts.

The outpatient facility's tardiness of the first cases of the day was compared among anesthesiologists and specialties. Analysis was limited to the 4512 scheduled first cases of the day. The components of the variance in tardiness that were attributable to the anesthesiologists and specialties were estimated using a random effects model and restricted maximum likelihood estimation. Each of the effects was estimated individually, while including a statistically significant (P = 0.002) but negligibly small (0.4 min increase per year) trend over time. Bonferroni correction was used for the comparisons among the n = 85 anesthesiologists and n = 14 specialties to assure overall $P < 0.05$ was significant. Statistical calculations were performed using Systat 12 (SYSTAT Software, San Jose, CA).

RESULTS

Each 1.0 min reduction in the tardiness of the first cases of the day in ORs with more than 8 h of cases and turnovers resulted in 1.1 ± 0.1 min reduction in regularly scheduled labor costs. This result was close to the 1.2 min obtained using the entirely different method summarized in the Introduction.[12] Additional reasons to expect the validity of our results were based on the following three characteristics of the studied facility.

First, the actual end of the regularly scheduled workday matched its official end (3:30 PM). As described in the Methods, between 60% and 66% of ORs should have finished by 3:30 PM, and the observed percentile was 63%.

Second, the percentage of first cases of the day starting late was larger than reported by other facilities.[21] Thus, the facility studied was one for which the analysis would be useful. There were 19% of cases starting 5 min or later than the scheduled start of the day, 14% of cases starting 10 min or later, and 7% of cases starting 15 min or later. The mean tardiness of start of the first cases of the day was 4.2 ± 0.1 min, both for ORs ending before and after 3:30 PM.

Third, the tardiness of starts of first cases of the day was distributed homogeneously among ORs. The proportions of the variance in tardiness attributable to anesthesiologists and specialties were only 1% and 3%, respectively. There were no statistically significant differences in tardiness among the 85 anesthesiologists or 14 specialties. In other words, the results were not skewed by the presence of a few bad actors.

DISCUSSION

Lack of knowledge of principles of maximizing the efficiency of use of OR time on the day of surgery and a psychological bias that most cases start late contribute to organizational focus on first case of the day starts.[2] These and our prior studies[13] do not mean that reducing tardiness of first case of the day starts matters little economically. At facilities with many ORs having more than 8 h of cases, improving on-time starts can matter a lot economically (e.g., by facilitating the reduction in staffing in some ORs from 10 to 8 h). We developed and validated a simple method through which analysts and/or clinicians can screen quickly (e.g., while in a meeting) for the economic impact of improving first-case starts. They can do so by using a typical estimate for the savings achievable from each 1 min reduction in the tardiness of first case of the day starts.[13] This estimate can be used to assess the value of performing a more complete and accurate analysis of the ROI of proposed measures to reduce first case of the day tardiness.

The method of estimating cost savings from reductions in tardiness of first case of the day starts uses the formula described in the Introduction, with a savings of 1.1 min for each 1 min reduction in tardiness (Table 1). The amount saved can then be used to estimate the breakeven cost for efforts proposed to reduced tardiness. For example, at the facility studied, 37% of the 6 ORs or approximately 2 ORs per day ran longer than 8 h each day and the average tardiness was 4.2 min per OR. We consider the average cost to staff an OR to be \$3.35/min.* Then, if somehow average tardiness could be reduced by 3 min in each OR with scheduled cases booked for longer than 8 h, estimated savings would be \$22.11/d, where \$22.11 = (1.1) × (3 min/OR) × (2 OR/d) × (\$3.35/min).

The full method of analysis in the Appendix treats OR labor costs as stepped, with the balance of fixed versus variable depending on the mean and standard deviation of each combination of specialty and day of the week.[11,13,17,20,25,26] To obtain an approximation simple enough for a calculator, we divided labor costs into purely fixed or variable. As described previously, ORs with few hours of cases are treated as having fixed labor costs[14–15,27]:

> Example #2: Our facility had an OR staffed from 7 AM to 3 PM. There was expected to be 7.0 h of cases. The first case of the day started 10 min late. There was no over-utilized OR time without or with the tardiness of the start of the first case of the day. Preventing the tardiness would have likely resulted in no incremental reduction in labor costs.

ORs with more than 8 h of workload are treated as having variable labor costs[11–15]:

> Example #3: Our facility had another OR staffed from 7 AM to 3 PM with expected 9 h of cases. The first case of the day started 10 min late, increasing the over-utilized OR time by 10 min. Each minute of over-utilized OR time cost 1.50 as much as each minute of regularly scheduled OR time. Thus, preventing the 10 min of tardiness would have effectively saved 15 min of labor costs.

Our work is important in determining, when this approximation is used, how many minutes of regularly scheduled time to be considered savable by each minute of reduction in tardiness of first case of the day starts for the ORs with more than 8 h of cases and turnovers. Our work should, however, be used only as a screening method. For example, suppose that a specialty has a mean OR workload of 9.3 h and a standard deviation of 0.5 h in one OR on a day of the week. Then, since it is unlikely that reducing tardiness of first case of the day starts could result in a reduction in staffing from 10 to 8 h, the labor costs are fixed despite the workload consistently exceeding 8 h.[13,26] The full method given in the Appendix takes this into account.

The economic screening method described applies equally well for facilities whose primary concern is growth in numbers of cases performed. For surgical suites with consistently fewer than 8 h of cases, it is unlikely that lack of OR time is the bottleneck to doing more cases. In contrast, for suites with at least 8 h of cases, this is a reasonable possibility. Some surgeons respond to small reductions in nonoperative OR time (e.g., faster inductions and shorter turnovers) with the scheduling of an additional case, thereby increasing revenue.[28–31]

Both the typical value that we estimated (Table 1) and the full analysis (Appendix) assume that facilities plan their specialty-specific staffing and schedule their cases based on minimizing the inefficiency of use of OR time.[13–17,20,25,26,32–34] This is important, because the increased cost from not making decisions that way is often so large (>10% of labor costs) that simply the uncertainty (i.e., width of the prediction interval) in the excess costs will likely exceed the average savings in having all first cases of the day start precisely when scheduled.[13,25,27,32]

Our estimate of typical cost savings from improving on-time starts was limited to the direct and intangible costs of OR labor, but not intangible costs that may be reduced[10,22,29] or increased,[29,35–37] by faster patient throughput. We do not know the sensitivity of our results to this nonstatistical error. We do know from observational studies that, among the four components of the screening equation given at the end of the Introduction, large differences among facilities will result from different proportion of ORs having more than 8 h of cases.[13,25,27,32,38–40]

APPENDIX

The following 11 step process was reviewed previously by McIntosh et al.[13]:

1. Turnover times were calculated between each pair of sequential cases in the same OR on the same day.

Each turnover time was attributed to the specialty of the surgeon of the completed case. Turnovers longer than 1 h were set equal to 1 h, since these likely represent the effect of case cancellations or scheduled delays between cases.

2. The OR workload was calculated for each specialty on each day using the most recent 10 four-week periods of data (3798 cases).[13,33]

The Ref. 39 is the statistical power analysis in which we showed that a 40 wk period is brief enough that the same allocated OR time can be planned for each specialty on each day of the week over the studied period, but sufficiently long to accurately calculate appropriate staffing.[13,33] There were some combinations of specialty and day for which the specialty had zero OR workload on that day but significant workload on other days of the same day of the week. Consequently, to get the correct allocations in the 4th step, below, we considered there to be a case of zero duration for all combinations of specialty and day. The impact was that our calculation of OR workload for each combination of specialty and day of the week included all studied days for that day of the week, including days for which the specialty had zero workload.

3. Each combination of specialty and day of the week with a mean OR workload <5.60 h was assigned to a pseudo-service representing open, unblocked, first-scheduled, first-served "OTHER" time for low workload services.[13]

The reason[16] for our use of 5.60 h was that $1.50 \times (2 \times 5.60 - 8.0\text{ h}) = 2 \times (8.0\text{ h} - 5.60)$. In other words, 5.60 h is the breakeven point in which two specialties scheduling into the same shared OR time would result in the same inefficiency of use of OR time as each having its own 8 h of allocated OR time.[16] Conveniently, none of the studied changes in OR times were of a sufficient magnitude to switch a combination of specialty and day of the week from a mean workload greater than 5.60 to <5.60 h. Thus, our results did not include any changes in the ORs into which cases were scheduled.

4. For each combination of specialty and day of the week, the total inefficiency of use of OR time among days was calculated for choices of allocated OR times of 0 h (0 ORs), 8 h (1 OR), 16 h (2 ORs), and 24 h (3 ORs).

The 24 h (3 ORs) was the current maximum for the specialty (orthopedics) with the largest workload at the facility. Validation of our use of only 8 h workdays for each OR was described above. The allocated numbers of ORs chosen for the combination of specialty and day of the week was the choice that minimized the total inefficiency of use of OR time among all days. This process and the criterion for selection were equivalent to our making the following three assumptions about case scheduling.[13,34] First, no changes would be made to the date at which each case was performed.[13,34] Second, a case would not be scheduled outside of a specialty's allocated OR time if the specialty had time for the case within its allocated time.[13,34] Third, cases would be scheduled into allocated time without scheduled gaps between successive cases (i.e., the maximum turnover time would be 1 h, as specified in Step #1).[13,41]

5. The mean OR labor cost among days was calculated for each of the 10 four-week periods, using the OR workloads from Step #2 and the OR allocations from Step #4.

For most 4-wk periods, the resulting value was the mean labor cost among 20 workdays. Because each 4-wk period had 3 or 4 days for each day of the week, depending on holidays, this process mitigated the effect on our results of variations among days of the week.[13,34]

6. To represent the effect of not having all first cases of the day entering their ORs on time, the start time of the first scheduled case in each OR was considered to be the start of the workday.[13]

All ORs had the same time of the start of the workday, but that time differed by 45 min among days of the week, which we incorporated in the analysis. There were 130 cases that: i) were first cases of the day in an OR ending after 3:30 PM, ii) were scheduled to start at the beginning of the workday, and iii) entered between 1 min and 1 h after the start of the workday. Those 130 cases had their times into the OR changed to the start of the workday.

7. Steps #2 to #5 were repeated using the data from Step #6, resulting in the mean OR labor costs for each of $n = 10$ four-week periods.
8. The $n = 10$ pairwise increases in OR labor minutes were calculated using the differences in results between Steps #7 and #5.[13,17,25,26]
9. The sum of the increases in OR times from Step #6 was calculated for each 4-wk period.
10. The increase in labor minutes for each 4-wk period from Step #8 was divided by the corresponding increase in OR time for the 4-wk period from Step #9.
11. The mean and standard error were calculated for the $n = 10$ ratios from Step #10.

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