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ECONOMICS, EDUCATION, AND HEALTH SYSTEMS RESEARCH: Research Report

Sampling Error Financial Performance Operating Room Time Allocation

Dexter, Franklin MD, PhD

[Author Information](#)

*Division of Management
of Anesthesiology, University
of Dalhousie University, Halifax

Franklin Dexter is employed
by several consulting
companies, and hospitals

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Address correspondence to

Department of Anesthesia, University of Iowa, Iowa City, IA 52242. Address e-mail to Franklin-Dexter@UIowa.edu.

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Metrics

Abstract

Hospitals with limited operating room (OR) hours, those with intensive care unit or ward beds that are always full, or those that have no incremental revenue for many patients need to choose which surgeons get the resources. Although such decisions are based on internal financial reports, whether the reports are statistically valid is not known. Random error may affect surgeons' measured financial performance and, thus, what cases the anesthesiologists get to do and which patients get to receive care. We tested whether one fiscal year of surgeon-specific financial data is sufficient for accurate financial accounting. We obtained accounting data for all outpatient or same-day-admit surgery cases during one fiscal year at an academic medical center. Linear programming was used to find the mix of surgeons' OR time allocations that would maximize the contribution margin or minimize variable costs. Confidence intervals were calculated on these end points by using Fieller's theorem and Monte-Carlo simulation. The 95% confidence intervals for increases in contribution margins or reductions in variable costs were 4.3% to 10.8% and 6.0% to 8.9%, respectively. As many as 22% of surgeons would have had OR time reduced because of sampling error. We recommend that physicians ask for and OR managers get confidence intervals of end points of financial analyses when making decisions based on them.

When physicians read clinical study reports, they often ask relevant statistical questions. For example, if an odds ratio is reported, there is an expectation that a confidence interval or *P* value should be provided to show whether the reported ratio differs significantly from 1.0. Physicians have also endorsed efforts to use statistical methods when medical outcomes are compared among hospitals and physicians. For example, two surgeons' mortality rates would not be said to differ unless the rates were risk-adjusted. Yet, curiously, hospital managerial accounting reports rarely include statistical analyses of the data. For example, two surgeons may appear to have very different financial effects on a hospital on the basis of their average costs

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of Anesthesiology, University of
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per case. However, the differences between the surgeons may be due only to random variation among patients. Although it would seem inadvisable to base operational change on inaccurate statistics, our experience is that confidence intervals are virtually never included in hospital managerial accounting reports. In this study, we tested whether one fiscal year of surgeon-specific financial data is sufficient to ensure that sampling error does not significantly affect surgeons' measured financial performance.

We focus on surgeons' contribution margin per hour. The former applies to managing the contribution margin is cut for each successive patient. The rest of hospital costs are surgical lights and OR rental. Accurately determining contribution margin is important not only for the hours of OR time, as costs are allocated less. Unless a hospital may exacerbate the purchasing of new equipment, a cycle can ensure more contribution margin is performed correctly and

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variable costs per OR hour (1,2). The latter would cut costs (1,3). The contribution margin that increase with nursing labor. The examples of these are

A hospital is not a hospital with fixed costs. Then another is not a hospital with fixed costs to surgeons, the contribution margin, reductions in contribution margin. A spiraling vicious cycle of services to generate contribution margin that OR allocations be

Methods

We obtained hospital accounting data for the study. The population was all patients undergoing outpatient or same-day-admit surgery during the 2000 fiscal year at a large academic multiple-specialty hospital in the southeastern United States. The data were extracted from the hospital's activity-based costing system (Transition 1™; Eclipsys Corp., Delray Beach, FL). Calculations were performed with Year 2000 US dollars.

We excluded from the study those patients who had been admitted before surgery. Thus, patients undergoing urgent or emergent cases were excluded. We excluded these patients because there is a commitment to provide timely care to a patient once he or she has been admitted to the hospital. Thus, such patients should not be considered in the allocation of OR time on the basis of financial criteria.

Overall variable costs, revenue, hours of OR time, hours of regular ward time, and hours of intensive care unit time were calculated for each physician. We limited the analysis to the 98 physicians at the hospital who performed at least 15 cases during the study year. This method limited consideration to surgeons (versus, for example, an occasional bone marrow donation performed by a hematologist). There were 9,184 cases, 28,290 h of OR time, US\$44.3 million of variable costs, and US\$40.6 million of contribution margin.

Linear Programming to Maximize Contribution Margin or Minimize Variable Costs

We used the Solver linear programming (4) routine in Microsoft Excel™ (Microsoft Corp., Redmond, WA) to find the mix of surgeons' OR time allocations to maximize the contribution margin or minimize variable costs. We included the following constraints on the availability of resources.

First, we assumed that each surgeon could expand his or her use of OR time by as much as one-quarter of the number of OR hours that he or she used during the past fiscal year. Second, we assumed that the OR time for a surgeon could be cut by as much as one-quarter. The surgeons at the hospital under study have privileges at only one hospital. Therefore, a maximum reduction of 25% was the lowest practical limit. Third, we specified that the total OR time used could not change. We thus kept the same OR utilization. Fourth, we added constraints specifying that nursing ward and intensive care use could not exceed that of the last year.

We used the sensitivity analysis feature of Excel's Solver tool to find the "allowable increase" in each surgeon's contribution margin per OR hour (4). This is the amount by which it would have had to have been larger for

the surgeon to have gotten a larger OR allocation.

Statistical Power Analysis Simulations for Contribution Margin

We used Fieller's theorem to obtain each surgeon's *a posteriori* probability distribution for mean contribution margin per OR hour. The variables used in Fieller's theorem were each case's contribution margin and OR time⁽⁵⁾. Each surgeon v

We calculated confidence intervals for the contribution margin by use of Monte-Carlo simulation. A random number generator from each simulation was used in the linear programming described previously. The expected increase in hospital contribution margin per OR hour was drawn. The process was repeated 49

A histogram was drawn of the contribution margin. The values were calculated to get 80%, 90%, and 95%

Next, we calculated the sensitivity analysis for the contribution margin per OR hour from the contribution margin

Using the method of the preceding paragraph, we divided the surgeons into two groups. One group was those for whom sampling error may have led to at least part of his or her cut in OR time. The other group was those for whom this was unlikely. We knew the numbers of cases performed by each surgeon during the 1-yr data period. We compared the numbers of cases performed during the year by surgeons in each of the two groups by using the Mann-Whitney *U*-test (SYSTAT 10.0; SPSS, Inc., Chicago, IL).

Statistical Power Analysis Simulations for Variable Costs

We used Monte-Carlo simulation to calculate confidence intervals on the expected reductions in hospital variable costs. The method we used was just as described previously for contribution margin, except that the linear programming aimed to minimize variable costs rather than maximize contribution margin.

Confidence intervals for the median pairwise differences in each surgeon's coefficients of variation of contribution margin versus variable costs were calculated with the Hodges-Lehmann method (StatXact-4; Cytel Software Corp., Cambridge, MA).

Results

[Figure 1](#) shows the effect of sampling error in contribution margin per OR hour on the expected increases in contribution margin from changing OR allocations. The 80%, 90%, and 95% confidence intervals for the expected increases in contribution margins were 5.4%–9.7%, 4.8%–10.3%, and 4.3%–10.8%, respectively.

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[Figure 1:](#)

Histogram of achievable increases in hospital contribution margins by appropriately allocating operating room time to surgeons. We made the histogram by using 1 yr of hospital financial data.

The upper 80%, 90%, and 95% confidence bounds on the percentages of surgeons for whom sampling error may have led to reductions in OR time were 12%, 18%, and 22%, respectively ([Fig. 2](#)). Those 22% of surgeons had a relatively small volume compared with the other surgeons. They had a mean \pm sd of 66 ± 70 cases during the year. The other surgeons performed 102 ± 74 cases ($P = 0.007$).

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Figure 2:

Percentages of surgeons for whom sampling error may have led to cuts in operating room (OR) time. First, we applied Fieller's theorem to each surgeon's cases to obtain an upper confidence bound for each surgeon's contribution margin per OR hour (5). Fieller's theorem uses an α value. For example, $\alpha = 0.50$ gives the 50% percentile, $\alpha = 0.05$ gives the 95% percentile, etc. These percentiles are the programming to find the "allowable increase" in the surgeon's contribution margin that would have gotten a larger OR upper confidence step. These percentiles are the programming to find the "allowable increase" in the surgeon's contribution margin that would have gotten a larger OR upper confidence step. These percentiles are the programming to find the "allowable increase" in the surgeon's contribution margin that would have gotten a larger OR upper confidence step.

Figure 3 shows the effect of variable costs from charitable reductions in variable costs.

Figure 3:**Figure 3:**

Histogram of achieving room time to surgeons.

The effect of sampling error on the variation of contribution margin was, on average, higher than his or her coefficient of variation of variable costs.

The median difference was 61% (95% confidence interval, 52%–72%; $n = 98$ surgeons).

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Discussion

Surgeon's effect on hospital financial performance can be measured by using variable costs per OR hour or contribution margin per OR hour^(1–3). Our results show that one year of financial data may not be adequate for making surgeon-specific OR management decisions on the basis of these metrics.

For example, at the hospital studied, allocating OR time on the basis of contribution margin per OR hour would probably increase the overall hospital contribution margin ([Fig. 1](#)). However, the range of the increase in contribution margin was relatively large, indicating that the actual effect on hospital performance can be difficult to determine with the available data. The 95% confidence interval was 4.3% to 10.8%. This range, of approximately 6.6%, translates to approximately US\$2.7 million. A potential increase in contribution margin of 4.3% may be too small in practice to be worth the political cost of changing OR allocations. A 10.8% increase is larger and so may be seen as sufficient. We doubt that there are clear cut-points for what percentage change in overall hospital contribution margin would be "worthwhile."

At the hospital studied, the surgeons who may have been affected by sampling error performed a mean \pm sd of 66 ± 70 cases during the year, or 1.3 cases per week. Some surgical facilities have a few surgeons on staff, each of whom performs an average of two or more cases per week. Our results suggest that one year of financial data would be adequate for OR management decision making at such unusual facilities. However, most facilities have more than one-quarter of their surgeons on staff who operate infrequently, averaging fewer than one case per week. When OR allocation decisions involve trade-offs among many surgeons, the small-volume surgeons cannot be excluded from the decisions because this would essentially mean excluding them from access to OR time.

We make the following recommendation. When OR allocation or hospital policy decision making will be made with one year of surgeon-specific financial data, and some surgeons performed fewer than an average of two cases per week, give confidence intervals along with the point estimates in hospital reports. Our Methods section shows how to do this. In that none of the authors are aware of a hospital that currently does this routinely, our work is important in showing the potential to improve the validity of operational planning.

Although one fiscal year of data may be insufficient, we do not recommend simply using more data. Over more than one year, practice patterns, hospital programs, cost accounting, and payer contracts tend to change. In that such variables can be difficult to account for, using longer periods can simply introduce other sources of error. We interpret our results as suggesting the need to measure the uncertainty in hospital managerial accounting reports.

Hospitals with fixed annual costs such as the allocation of overhead per OR hour were less than the width of 6.6% of the interval for the reduction in OR hour, one year of fixed calculations of confidence

Comparison to Real-World Data

Much more data are needed. Several years of data may be needed for hospitals to create reports that these results are meaningful.

Limitations

We performed the analysis with the knowledge that confidence intervals may be available. For example, specialty-specific national averages may be useful. Alternatively, data from one large-volume surgeon of a specialty could be extrapolated to provide insight into the financial performance of a small-volume surgeon of the same specialty. These so-called Bayesian methods could be studied in the future.

Our work applies to hospitals with limited hours of OR time available for elective cases. An example of this is a hospital at which a surgeon allocated eight hours of block time on Wednesdays can book only eight hours of elective cases that day. At some other hospitals, the surgeons and patients can schedule their elective cases on whatever future workday they choose⁽⁷⁻⁹⁾. Then our results would not apply. The linear programming method that we used assumes that there are fixed hours of OR time.

Our results also do not apply to hospitals that perform all elective cases within a “reasonable” (not decided by the surgeon) number of days^(6,10). At such hospitals, the objectives in OR management are to maximize OR efficiency, maximize staff productivity, and minimize staffing costs. In such circumstances, comparing surgeons’ financial performance is unlikely to change OR managers’ decision making.

Conclusions

OR managers can use hospital accounting data for management decision making. The data can also be used to allocate OR block time^(1,2). Still, even when a full fiscal year of data is available, sampling error can significantly affect measured hospital financial performance of surgeons. This depends on how often the surgeon operates at the hospital. Calculation of confidence intervals for key financial variables is appropriate for management decision making.

References

1. Dexter F, Blake JT, Penning DH, Lubarsky DA. Calculating a potential increase in hospital margin for elective surgery by changing operating room time allocations or increasing nursing staffing to permit completion of more cases: a case study. *Anesth Analg* 2002; 94: 138-42.

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ditional *a priori* o make confidence

2. Macario A, Dexter F, Traub RD. Hospital profitability per hour of operating room time can vary among surgeons. *Anesth Analg* 2001; 93: 669–75.

- [Cited Here](#) |
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3. Dexter F, Blake JT, P hospital's operating ro

- [Cited Here](#) |
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4. Ragsdale CT. *Spreads* 2nd ed. Cincinnati: Sou

- [Cited Here](#)

5. Briggs AH, Mooney C evaluation of parametri 3245–62.

- [Cited Here](#) |
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6. Dexter F, Macario A, operating room block ti surgical waiting time. A

- [Cited Here](#) |
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7. Strum DP, Vargas LG, May JH. Surgical subspecialty block utilization and capacity planning: a minimal cost analysis model. *Anesthesiology* 1999; 90: 1176–85.

- [Cited Here](#) |
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8. Dexter F, Traub RD. Determining staffing requirements for a second shift of anesthetists by graphical analysis of data from operating room information systems. *AANA J* 2000; 68: 31–6.

- [Cited Here](#) |
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9. Dexter F, Epstein RH, Marsh HM. Statistical analysis of weekday operating room anesthesia group staffing at nine independently managed surgical suites. *Anesth Analg* 2001; 92: 1493–8.

- [Cited Here](#) |
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10. Dexter F, Macario A, O'Neill L. Scheduling surgical cases into overflow block time: computer simulation of the effects of scheduling strategies on operating room labor costs. *Anesth Analg* 2000; 90: 980–6.

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