Sampling Error Can Significantly Affect Measured Hospital Financial Performance of Surgeons and Resulting Operating Room Time Allocation

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Sampling Err… Hospital Financial Per… Operating Room Time A…

Dexter, Franklin MD, P…

Author Information

*Division of Manageme… …a City; †Department of Anesthesiology, Univ… …trial Engineering, Dalhousie University, H…

Franklin Dexter is employed by the University of Iowa, in part as a consultant to anesthesia groups, companies, and hospitals.

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Address correspondence and reprint requests to Franklin Dexter, Division of Management Consulting, 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 whe ns. For example, two
surgeons' mortality rate 'et, curiously,
hospital managerial acc example, two
surgeons may appear to heir average costs
per case. However, the ation among
patients. Although it wo atistics, our
experience is that confi l accounting reports.
In this study, we tested ient to ensure that
sampling error does not

We focus on surgeons' h variable costs per OR
hour. The former applie rgins [1,2]. The latter
applies to managing the cut costs [1,3]. The
contribution margin is hat increase with
each successive patient nursing labor. The
rest of hospital costs are amples of these are
surgical lights and OR r

Accurately determining hospital is
important not only for t ospitals with fixed
hours of OR time, as co then another is
allocated less. Unless a s to surgeons, the
hospital may exacerbate vices, reductions in
the purchasing of new capital equipment, and reductions in anesthesiologists' revenues. A spiraling vicious cycle can ensure more cuts, further reducing the hospital's capability to provide sufficient services to generate the contribution margin needed to cover its fixed costs. It is important for all concerned that OR allocations be performed correctly and accurately.

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 ... se" in each surgeon's contribution margin pe... ave been larger for the surgeon to have got...

Statistical Power ...

We used Fieller's theore... or mean contribution margin per OR hour. Th... n margin and OR time [5]. Each surgeon v...

We calculated confiden... gin by use of Monte-Carlo simulation. A ran... ndom-number generator from each su... aph). The linear programming describe... age increase in hospital contribution m... hour was drawn. The process was repeated 4...

A histogram was drawn ... in hospital contribution margin. Th... alues were calculated to get 80%, 90%, and 9...

Next, we calculated the ... iginal linear programming and for whom sampling error may have been the cause. Specifically, the sensitivity analysis described in the preceding section gave the largest increase that each surgeon's contribution margin could take on without affecting the original linear programming solution [4]. We compared these values with the differences between (a) the 80%, 90%, or 95% upper confidence bounds of each surgeon's contribution margin per OR hour from his or her *a posteriori* probability distribution and (b) his or her point estimate of the contribution margin per OR hour.

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.

F1-32

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 vo … f 66 ± 70 cases during the year. The oth …

F2-32
Figure 2:
Percentages of sur … room (OR) time. First, we app … confidence bound for each su … es an α value. For example, α = … etc. These percentiles are the … ' data in linear programming to f … n margin. Linear programm … ed the "allowable increas … hows how large the surgeon's cont … n to have gotten a larger OR … s for whom the upper confidence … rom the second step. These percen … indicate ±1 se.

Figure 3 shows the effec … reductions in variable costs from char … ls for the expected reductions in variable c …

F3-32
Figure 3:
Histogram of achievable reductions in hospital variable costs by appropriately allocating operating room time to surgeons. We made the histogram by using 1 yr of hospital financial data.

The effect of sampling error on uncertainty in expected reductions in variable costs was less than the effect of sampling error on uncertainty in the expected increases in contribution margin. Each surgeon's coefficient of 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).

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 ± 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 [...] ently does this routinely, our work is in [...] tional planning.

Although one fiscal year [...] more data. Over more than one year, pra[...] tracts tend to change. In that such var[...] nply introduce other sources of error. We int[...] nty in hospital managerial accounting [...]

Hospitals with fixed an[...] ve decision making, such as the allocation o[...] ion of variable costs per OR hour were less t[...] % confidence interval for the reductio[...] 5%. This was smaller than the width of 6.6% [...] ng variable costs per OR hour, one year of fi[...] sion making, calculations of confiden[...]

Comparison to R[...] tion

Much more data are ne[...] fic OR utilizations. Several years of data m[...] urgeons [6]. Many hospitals create reports [...] idence intervals show that these results are misleading [...].

Limitations

We performed the analyses using surgeon-specific hospital accounting data. However, additional *a priori* knowledge may be available about a surgeon's financial performance that could be used to make confidence intervals narrower. 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.

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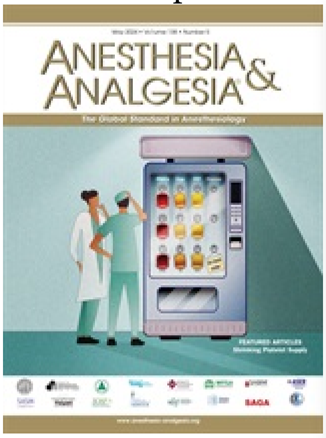

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