

Monitoring cancellation rates on day of surgery

Case cancellations in the 24 hours before surgery are undesirable—they are also unavoidable. To find out if their cancellation rate is high, many facilities benchmark their cancellation rates with others. Yet the usual way of monitoring cancellation rates can result in poor decision making.

If you are benchmarking cancellation rates without confidence levels, there is a good chance of finding that some hospitals have higher or lower cancellation rates than others—not because they truly do but simply because of random error. If you have not calculated the confidence level, you will not know whether your estimate of the cancellation rate is accurate. If you do not know if an estimate is accurate, there is a good chance of implementing processes that waste everyone's time, including additional paperwork, phone calls, and laboratory and diagnostic testing.

Because cancellations hopefully are rare events, estimates of cancellation rates should always be reported with the corresponding confidence interval.

How to monitor cancellation rates for electively scheduled cases has not been studied previously. This is a summary of findings of a recent study that my colleagues and I published that describes statistical methods for calculating cancellation rates.

Consider the following example, which illustrates that the usual way of calculating the confidence level is not accurate.

A surgical suite in a tertiary care hospital finalizes its OR schedule at 3 pm the day before surgery. The overall cancellation rate for cases on the final schedule is 10%. The anesthesiologists report frustration with cardiothoracic cases being cancelled. But details are sketchy, based on anecdotes. The cancellations seem to be caused mostly by the intensive care unit filling with medical patients.

Data from cardiothoracic surgery are reviewed. During the past month, the service scheduled 120 cases and performed 105, for an estimate of the cancellation rate of 13%, where $13\% = 100\% \times (1 - 105/120)$.

The estimate of 13% does not seem to be much worse than the overall cancellation rate of 10%. The true (actual) cancellation rate may be higher or lower than this estimate, however. The way to judge whether the estimate is reliable is by calculating the confidence interval. The manager uses her statistics software package to calculate the 95% confidence interval for the percentage. The statistics package uses the Clopper-Pearson method, a standard method built into many statistics packages. The confidence interval can also be calculated using an Excel formula.

To calculate the 95% confidence interval for the cardiothoracic surgery cancellation rate, the 2 numbers used are the 120 cases scheduled and the 105 cases completed. The 95% confidence interval for the cancellation rate is 7% to 20%. Even if the true cancellation were as high as 20%, it would still be possible to have as many as 105 cases completed out of 120 cases scheduled. This holds true, however, only if the confidence interval is accurate. Our paper shows that it is not (below).

The table shows that estimates of the cancellation rate vary markedly among 4-week periods, from as low as 6% to as high as 23%.

Calculating cancellation rates accurately

To measure the cancellation rate accurately, follow the steps in the table:

1. Determine the number of cases scheduled and the number of cases performed within each of six 4-week periods.

2. Apply the Freeman-Tukey double arcsin transformation to calculate a single number for each of the six 4-week periods. The equation is given in the appendix of our paper. The value can be calculated using a calculator or a spreadsheet program like Excel.

3. Calculate the confidence interval for the mean of the 6 numbers using Student t distribution. This method is built into every statistics package.

4. Take the inverse of the transformed value of the lower confidence bounds for the mean. Take the inverse of the transformed value of the upper confidence bound, too. For the cardiothoracic surgery cases, the true rate of cancellation is between 10% and 29%.

As the table shows, the range of 10% to 29% is so wide that very little is known about the true cancellation rate for cardiothoracic surgery at the hospital. That is the point of the calculation. The value of calculating the confidence interval is in knowing whether your estimate is accurate. If you do not know if an estimate is accurate, there is a good chance of implementing processes that waste everyone's time. Because cancellations hopefully are rare events, estimates of cancellation rates should always be reported with the corresponding confidence interval.

The scientific issues we studied included why the method used to calculate confidence intervals that is built into most statistical packages is inaccurate for monitoring surgical cancellation rates. The typical method is fine for estimating the percentage risk of a patient's case being cancelled because of a medical event. That would apply when the fact that one patient's case was cancelled does not change the probability that other patients have their surgeries cancelled. For example, Mr Johnson developing chest pain in the holding area before his inguinal hernia repair does not influence the probability that Mrs Cunnah will have an elevated temperature and white count before her aortic valve replacement. Yet that is not the reason for most cancellations among adults. Rather, most cancellations are due to administrative events, for which single causes can result in more than one case being cancelled. For example, referring to the data in the table, when the cardiothoracic

intensive care unit fills, several cardiothoracic cases on that day are cancelled. If the ICU fills on average once every 2 weeks, and cancellations are being compared from one 4-week period to the next, the cancellation rate will appear to vary markedly from one period to the next, leading to poor management decisions.

The same principle applies to comparing cancellation rates before and after making a change.

The straightforward way to track whether the cancellation rate truly has changed over time is to use Fisher's Exact Test or the chi-square test. However, these are inappropriate methods for monitoring changes in surgical cancellation rates, resulting in markedly incorrect answers. Instead, Student's t-test should be used after transformation of the data as illustrated in the table.

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Reference

Dexter F, Marcon E, Epstein R H, Ledolter J. Validation of statistical methods to compare cancellation rates on the day of surgery. *Anesthesia & Analgesia*. 2005;101: 465-473.

Table. Example of Calculating Confidence Interval for Cancellation Rate

Four-week period:	1 st period	2 nd period	3 rd period	4 th period	5 th period	6 th period
	Jan 3 to Jan 28	Jan 31 to Feb 25	Feb 28 to Mar 25	Mar 28 to Apr 22	Apr 25 to May 20	May 23 to Jun 17
Cancelled	16	23	7	27	22	15
Scheduled	117	114	121	116	127	120
Cancellation Rate	14%	20%	6%	23%	17%	13%
Transformed value	0.41	0.53	0.26	0.59	0.48	0.39

N = 6, sample mean = 0.44, sample standard deviation = 0.12
 Inverse of 0.44 = 18%, which is estimate of cancellation rate

Two-sided *t*-statistic with 5 degrees of freedom from Excel or statistics table = 2.57

95% lower confidence interval for transformed value = $0.44 - 2.57 \times 0.12 / \sqrt{6} = 0.32$
 Inverse of 0.32 = 10%, which is lower confidence bound of cancellation rate

95% upper confidence interval for transformed value = $0.44 + 2.57 \times 0.12 / \sqrt{6} = 0.56$
 Inverse of 0.56 = 29%, which is upper confidence bound of cancellation rate