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CHAPTER ELEVEN: CALCULATION OF HOSPITAL OUTCOME MEASURES

The risk adjustment models described in Chapter Nine were used to calculate several hospital outcome measures. The actual values of these measures for specific hospitals are reported in the *Detailed Statistical Tables* available under separate cover from OSHPD. Volume One of this report classifies all hospitals as "significantly better than expected," "significantly worse than expected," or "not significantly different than expected," using these outcome measures. Each outcome measure is listed below, with a detailed description and the methods used to calculate it, where appropriate.

OBSERVED NUMBER AND RATE OF ADVERSE OUTCOMES

The observed number of adverse outcomes at a hospital equal the number of deaths among qualifying AMI patients. The observed rate of adverse outcomes at a hospital equal the observed number of deaths, divided by the total number of qualifying patients at that hospital. This quantity was multiplied by 100 to yield a percentage.

EXPECTED NUMBER AND RATE OF ADVERSE OUTCOMES

The expected number of adverse outcomes at a hospital equal the sum of the expected probabilities of death for all of its qualifying patients. These expected probabilities were calculated using the logistic formulas in Chapter Nine. For example, the expected number of AMI deaths would be 5 if a hospital had 10 patients, each of whom had a 50% risk of death, or if a hospital had 100 patients, each of whom had a 5% risk of death.

The expected rate of adverse outcomes at a hospital equal the expected number of deaths, divided by the total number of qualifying patients at that hospital. This quantity was multiplied by 100 to yield a percentage. The expected rate of adverse outcomes also can be viewed as the mean expected probability of death across all patients at a hospital. It is a measure of the average severity of illness at that facility. If the expected outcome rate at a hospital is higher than the state-wide rate, then patients at that hospital tend to be high risk than the overall population of patients. If the expected outcome rate at a hospital is lower than the state-wide rate, then patients at that hospital tend to be lower risk than the overall population of patients.

RISK-ADJUSTED OUTCOME RATE

The risk -adjusted (or indirectly standardized) outcome rate at a hospital equals the statewide rate, multiplied by the ratio of the observed number of deaths to the expected number at that hospital:¹

$$I_i = S (E_j O_{ij} / E_j E_{ij})$$

where I_i is the indirectly standardized outcome rate for the i th hospital, S is the statewide outcome rate, O_{ij} is the observed value of the adverse outcome (0 or 1) for the j th patient at the i th hospital, and E_{ij} is the expected probability of the adverse outcome for the j th patient at the i th hospital. The latter two variables are summed over all patients at the i th hospital.

This risk -adjusted outcome rate provides a basis for comparing the performance of different hospitals, because each hospital's rate is adjusted to reflect what its outcome rate would be if its patients were about as ill as the statewide average. The ratio of the observed number of adverse outcomes to the expected number at a hospital provides a quick method for assessing a single hospital's performance. For a hospital with fewer observed than expected deaths, this ratio is less than one; for a hospital with more observed than expected deaths, this ratio is greater than one.

CONFIDENCE LIMITS FOR RISK -ADJUSTED OUTCOME RATES

The 95% confidence limits reflect the level of confidence in a hospital's risk -adjusted outcome rate. Assuming that the risk model is correct, there is a 95% chance that a hospital's true risk -adjusted outcome rate falls within these confidence limits. In general, when the upper and lower confidence limits are far apart, the estimated risk -adjusted outcome rate is unreliable.

These 95% confidence limits were constructed from the standard deviation of the observed number of deaths at each hospital:

$$\text{Lower CI}(I_i) = (S / E_j E_{ij}) \text{ MAX}(0, E_j O_{ij} - 1.96 [E_j (E_{ij}) (1 - E_{ij})]^{0.5})$$

$$\text{Upper CI}(I_i) = (S / E_j E_{ij}) \text{ MIN}(n_j, E_j O_{ij} + 1.96 [E_j (E_{ij}) (1 - E_{ij})]^{0.5})$$

¹Williams RL. Measuring the effectiveness of perinatal medical care. *Medical Care* 1979;17:95 - 110.

where I_{ij} , O_{ij} , and E_{ij} are defined as before. The lower confidence limit is constrained so it does not fall below 0%; and likewise the upper confidence limit is constrained not to exceed 100%.

In estimating the standard deviation of the observed number of adverse outcomes, the expected probability of that outcome for each case was treated as a fixed quantity. These expected probabilities were derived from regression models that included all eligible patients in California. With such large samples, random prediction error is difficult to compute and negligible in comparison with other variance components.² The statewide outcome rate also was treated as a fixed quantity. Therefore, the confidence intervals were constructed around the observed number of adverse outcomes, which was treated as a random variable. Because there is considerable variability within hospitals in the expected probabilities of the adverse outcome, the variance formula used is based on the expected probabilities for individual patients rather than the average expected risk at a hospital.

EXACT PROBABILITY OF OBSERVED NUMBER OF ADVERSE OUTCOMES

The exact probability of the observed number of adverse outcomes (or a more extreme number) occurring by chance, given the expected number of adverse outcomes at a hospital, was used to identify the exceptional hospitals labeled with stars in Volume One. This approach differs from the more widely used normal approximation in that it gives better estimates for hospitals with relatively small expected numbers of adverse outcomes.³

If the observed number of deaths exceeded the expected number, an upper probability (p) value was computed. If the observed number of deaths was less than or equal to the expected number, a lower probability (p) value was computed.

The upper p-value for a hospital is the probability that the observed number of deaths or more occurred by chance. The upper p-value represents a "test" of whether a hospital has systematically worse outcomes than the statewide average. A very small p-value of 0.001 means that one would expect to observe so many adverse outcomes or more only 1 time in 1000, by chance. A more likely explanation for such an extreme finding would be quality of care or some other systematic factor.

²Health Care Financing Administration. *Medicare Hospital Mortality Information, 1988 - 1989 - 1990, Volume 55*. Washington, D.C.: US Government Printing Office.

³Luft HS, Brown BW Jr. Calculating the probability of rare events: Why settle for an approximation? *Health Services Research* 1993;28:419 -439.

The lower p -value for a hospital is the probability that the observed number of deaths or fewer occurred by chance. The lower p -value represents a "test" of whether a hospital has systematically better outcomes than the statewide average.