EXPLAINING 95% CONFIDENCE INTERVALS

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Purpose: Provide a more in depth explanation of Confidence Intervals for the Hospital Associated Infections Report using examples to assist the reader.

95% Confidence Intervals: The tables concerning hospital infections presented on this web site display, for example, the types of procedures studied, the number of procedures, the number of infections, and then the rates of infections expressed either as the number of infections per 100 procedures (percent) or the number of infections per 1000 procedures. The tables also display *95% confidence intervals.* These are meant to help readers get a truer sense of the "precision" of the reported rates and of the range in which the "true rate" of infections may lie. The term *"confidence interval"* is familiar to statisticians who are professionally trained to analyse and evaluate the meaning of data but may not be familiar to others. However, a more familiar term, the so-called *"survey margin of error"*, is closely related to the term *95% confidence intervals.* For example, before elections, newspaper articles often report polls about what percent of voters say they plan to vote for a particular candidate. Those articles often include information about the *margin of error* about the reported percents. What this means is that the true percentage of persons who plan to vote for a candidate is not known with certainty; that the poll gives an estimate of the true percentage; but that the poll – like all survey data -- has a *"margin of error"*. For example, if a poll says that 60 percent of voters say they plan to vote for candidate X and that the *margin of error* of the poll is plus or minus 4 percent, this means that it is very likely (95% likely) that the true percentage of voters who plan to vote for candidate X lies within 4 percent of the reported 60 percent, or somewhere in the interval between 56 percent and 64 percent. In fact, this range of "56 to 64" is equivalent to the *95% confidence interval.* Newspaper readers usually well appreciate that the "margin of error" of a political poll depends in part on the number of persons polled. For example, a poll which only interviews 10 persons will not be as accurate as a poll which interviews 1000 persons. Therefore, a poll of 10 persons will give a result which has a large *margin of error*. In almost exactly the same way, hospital infection rates calculated only on the basis of a small number of procedures will not be as accurate as rates calculated for a large number of procedures, and *margins of errors* will be large and *95% confidence intervals* will be wide. Political polls based on a small number of interviews may produce misleading or inaccurate results, and the same principle applies to infection rates based on small numbers of procedures. Fortunately, with an ongoing program of monitoring hospital infections, more and more data can be accumulated, and over time information about observed infection rates may become more precise.

Interpretation of infection rates and 95% confidence intervals:

Example 1: A hospital performed a certain surgical procedure 50 times. Infections occurred after 2 of those procedures. The infection rate is 4 infections per 100 procedures with 95% confidence Intervals of 0.7 to 14.9.

- **Simple interpretation: "**2 infections out of 50 procedures = 4%. Therefore the infection rate per 100 procedures = 4"

- **Better interpretation: "**The observed infection rate was 4 infections per 100 procedures which provides an estimate of the true, but unknown underlying infection rate for the procedure. Though the true underlying rate is not known for sure, the 95% confidence interval runs from 0.7 to 14.9. This means that there is a 95% certainty that the true underlying infection rate lies somewhere in the interval between 0.7 and 14.9 infections per 100 procedures. As larger numbers are accumulated over time, calculated 95% confidence intervals will become narrower, and it may become possible to obtain a more precise estimate of the true underlying infection rate."

Example 2: Hospital A performed a procedure 35 times in the past six months and noted 2 infections. Observed rate of infection 2/35 = 5.7 infections per 100 procedures, with 95% confidence interval of 1.0 to 20.5. Hospital B performed the same procedure 70 times and noted 5 infections giving an observed infection rate of 7.1 per 100 procedures with 95% confidence interval of 2.7 to 16.6)

- **Incorrect interpretation: "**Hospital B had an observed rate of 7 infections per 100 procedures while Hospital A had a rate of 5.7 infections per 100 procedures. Therefore the infection rate in Hospital B must be higher than the rate in hospital A."

- **Better and more correct interpretation: "**Hospital B's observed rate was slightly higher than Hospital A's rate, but in both cases (a) the 95% confidence intervals were wide; (b) there is considerable overlap of the confidence intervals, and (c) each hospital's observed rate is contained within the other hospital's confidence interval. Because of this, and because the "margin of error" in both cases is so wide, <u>it is not possible to state that the underlying rates of infection are different.</u> However, as more data are accumulated over time, it may become possible to tell whether one hospital's infection rate is really likely to be different than the others."

- **Schematic visual display:** numbers shown are rates per 100. The number by the "X" shows the observed rate per 100. Numbers at the end of the line segments show the upper and lower bound of the calculated 95% confidence intervals, also expressed as infections per 100.

```
Hospital A       |-----------------------X------------------------------------|
35 procedures    1.0                     5.7                                  20.5
  2 infections

Hospital B:          |---------------------------X------------------------|
70 procedures        2.7                         7 .1                     16.6
  5 infections
```

Example 3: Hospital M performed a procedure 100 times and noted 10 infections. Observed rate of infection is therefore 10.0 infections per 100 procedures with 95% confidence interval of 5.1 to 18.0 Hospital B performed the same procedure 200 times and noted 2 infections. Observed rate of infection = 2/200 = 1.0 infection per 100 procedures with 95% confidence interval 0.2 to 3.9.

- **Schematic visual display:** numbers shown are rates per 100. The number by the "X" shows the observed rate per 100. Numbers at the end of the line segments show the upper and lower bound of the calculated 95% confidence intervals, also expressed as infections per 100.

```
Hospital M:                          |-----------------------X------------------------------------|
  100 procedures                     5 .1                    10.0                                18.0
  10  infections


Hospital N:      |-----X-------------|
  200 procedures 0.2   1.0           3.9
  2 infections
```

- **Interpretation:** "The observed infection rate in Hospital N (1 infection per 100 procedures) was less than the observed rate in Hospital M (10 infections per 100 procedures). Furthermore, in this case, the 95% confidence intervals do NOT overlap, and the observed infection rates for each hospital are NOT included within each other's 95% confidence intervals. Here, it does seem possible to conclude that the infection rate in hospital N is significantly lower than the rate in hospital M. The fact that these hospitals in this example reported on more procedures than did the hospitals in Example 2, led to a narrowing of the calculated *95% confidence intervals* and this in turn facilitated the comparison."

Technical Note: Various formulas are used by statisticians to calculate 95% confidence intervals. Introductory textbooks on statistics often present a simple formula for what is called the Wald Method. That method is satisfactory in many situations, but is felt to be not very accurate either when samples are small or when the observed proportions are close to 0 or 100. In those settings, other more sophisticated formulas are more accurate. Different formulas give slightly different answers but are usually in very close agreement with one another. The method used here is sometimes called the *Fleiss Quadratic Method* as it was presented in a standard textbook by J. L. Fleiss – *Statistical Methods for Rates and Proportions* – John Wiley and Sons, 2nd edition, 1981 (p. 13-15). Several statistical calculators which perform similar 95% confidence interval calculations can also be found on the Internet though some are better than others. One helpful found at http://faculty.vassar.edu/lowry/prop1.html performs calculations using two methods, the second of which provides results virtually identical to those of the *Fleiss method* used here.