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Statistical Inference

Inference is about using facts we know to learn about facts we do not know. *Statistical inference* is about examining a small piece of the world to learn about the entire world, along with evaluating the quality of the inference we reach. The "small part" is called a sample; the "world" is called a population.

We confront statistical inferences almost daily. When we open a newspaper, for example, we may find the results of a survey showing that 70% (95% CI ± 5) of American voters have confidence in the U.S. President. Or we may read about a scientific study indicating that a daily dose of aspirin helps 60% (95% CI ± 3) of Americans with heart disease. (See below for more on the meaning of 95% CI ± .)

In neither of these instances, of course, did *all* Americans participate. The pollsters did not survey every voter; and the scientists did not study every person with heart problems. They rather made an inference about all voters and all those stricken with heart disease by drawing a sample of voters and of ill people.

Why analysts draw samples is easy to understand: it may be too costly, time consuming, or even inefficient to study all the people in the target population—all voters or all people with heart disease. More difficult to understand is how researchers make a statistical inference (e.g., 70% of all American voters have confidence in the President) and assess its quality (that is, indicate how uncertain they are about the 70% figure, as indicated by the ± 5%). It is one thing, in other words, to say that 70% of the voters *in the sample* have confidence in the President; but it is quite another to say that 70% of *all* voters have confidence. To support the first claim, all the analysts need do is tally the responses to their survey; to support (and evaluate) the second, they must (1) draw a *random probability sample* of the population of interest and (2) determine how certain (or uncertain) they are that the value they observe from their sample of voters (e.g., 70%)—called the sample statistic—reflects the population of voters—called the population parameter.

A random probability sample involves identifying the population of interest (e.g., all American voters) and selecting a subset (the sample) according to known probabilistic rules. To do this each member of the population must be assigned a selection probability, and selection into the observed sample must be done according to these probabilities. (Collecting all the observations is a special case of random selection with a selection probability of 1.0 for every element in the population.) Several different forms of random probability sampling exist but the important point is that random selection is the only selection mechanism (in large-*n* studies) that automatically guarantees the absence of bias in the sample; that is, it guarantees that the sample is representative of the population. This is crucial because if a sample is biased (e.g., if Democrats had a better chance of being in the pollsters' sample than Republicans) we cannot draw accurate conclusions.

Assuming researchers draw a random probability sample, they can make an inference about how well their sample reflects the population or, to put it another way, they can convey their degree of uncertainty about the sample statistic (e.g., 70%). Surveys reported in the press, for example, typically convey this degree of uncertainty as "the margin of error," which is usually a 95% confidence interval (or, as we have written above, 95% CI). So when pollsters report the results of a survey—for example, that 70% of the respondents have confidence in the President with a $\pm$ 5 margin of error—they are supplying the level of uncertainty they have about the sample statistics of 70%: here, that the true fraction of voters having confidence in the president will be captured in the stated confidence interval in 95 of 100 applications of the same sampling procedure. Note that this information does not tell us exactly where the population (parameter) lies within this range. What is critical, though, is that if we continue to draw samples from population of voters, the mean of the samples of voters will eventually equal the mean of the population, and if we graphed the mean of each sample, we would see a shape resembling a normal distribution. This is what enables us to make an inference—here, in the form of a sample statistic and a margin of error—about how all voters feel about the president (the population) by observing a single sample statistic (70%).

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Further reading:

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Barnett, Vic. 1999. *Comparative Statistical Inference, 3rd Edition.* New York: Wiley.

Epstein, Lee and Gary King. 2002. "The Rules of Inference." *University of Chicago Law Review* 69: 1-133.