STAT 345 - Sampling Handout
BASED ON SECTIONS: 6.2

Sampling and Nonsampling Errors

from *Sampling: Design and Analysis* by Sharon L. Lohr, pp.15–6

Most opinion polls that you see report a *margin of error*. Many merely say that the margin of error is 3 percentage points. Others give more detail, as in this excerpt from a *New York Times* poll: "In theory, in 19 cases out of 20 the results based on such samples will differ by no more than three percentage points in either direction from what would have been obtained by interviewing all Americans." The margin of error given in polls is an expression of **sampling error**, the error that results from taking one sample instead of examining the whole population. If we took a different sample, we would most likely obtain a different sample percentage of persons who visited the public library last week. Sampling errors are usually reported in probabilistic terms, as done above by the *New York Times*.

Selection bias and inaccuracy of responses are examples of **nonsampling errors**, which are any errors that cannot be attributed to the sample-to-sample variability. In many surveys, the sampling error that is reported for the survey may be negligible compared with the nonsampling errors; you often see surveys with a 30% response rate proudly proclaiming their 3% margin of error, while ignoring the tremendous selection bias in their results.

The goal of this chapter is to sensitize you to various forms of selection bias and inaccurate responses. We can reduce some forms of selection bias by using probability sampling methods, as described in the next chapter. Accurate responses can often be achieved through careful design and testing of the survey instrument, training of interviewers, and pretesting the survey.

Why Sample at All? With the abundance of poorly done surveys, it is not surprising that some people are skeptical of *all* surveys. "After all," some say, "my opinion has never been asked, so how can the survey results claim to represent me?" Public questioning of the validity of surveys intensifies after a survey makes a large mistake in predicting the results of an election, such as in the *Literary Digest* survey of 1936 or in the 1948 U.S. presidential election in which most pollsters predicted that Dewey would defeat Truman. A public backlash against survey research occurred again after the British general election of 1992, when the Conservative government won reelection despite the predictions from all but one of the major polling organizations that it would be a dead heat or that Labour would win. One member of Parliament expressed his opinion that "extrapolating what tens of millions are thinking from a tiny sample of opinions affronts human intelligence and negates true freedom of thought."

Some people insist that only a complete census, in which every element of the population is measured, will be satisfactory; this objection to sampling has a long history. When Anders Kiaer (1897), director of Norwegian statistics, proposed using sampling for collecting official government statistics, his proposal was by no means universally well received. Opponents of sampling argued that it was dangerous and that samples could never replace a census. Within a few years, however, the international statistical community was largely persuaded that representative samples are a good thing, although probability samples were not widely used until the

1930s and 1940s.

For small populations, a census may of course be practical. For example, if you want to know about the employment history of 1990 Arizona State University graduates who majored in mathematics, it would be sensible to try to contact all of them. If all graduates respond, then estimates from the survey will have no sampling error. The estimates will have nonsampling errors, however, if the questions are poorly written or if respondents give inaccurate information. If some of the graduates do not return the questionnaire, then the estimates will likely be biased because of nonresponse.

In general, taking a complete census of a population uses a great deal of time and money and does not eliminate error. The biggest causes of error in a survey are often undercoverage, nonresponse, and sloppiness in data collection. Most of us have kept a checkbook register at some time, which is essentially a census of all check and deposit amounts. How many of us can say that we have never made an error in our checkbooks? It is usually much better to take a high-quality sample and allocate resources elsewhere, for instance, by being more careful in collecting or recording data, doing follow-up studies, or measuring more variables.

After all, the *Literary Digest* poll predicted the vote wrong even in some counties in which it attempted to take a census. The decennial census, which attempts to enumerate every U.S. resident, misses segments of the population. For the year 2000 census, a panel from the National Academy of Sciences has recommended that enumeration be combined with sampling to improve the accuracy of the census. Congress is currently debating this proposal.

There are three main justifications for using sampling:

- Sampling can provide reliable information at far less cost than a census. With probability samples, you can quantify the sampling error from a survey. In some instances, an observation unit must be destroyed to be measured, as when a cookie must be pulverized to determine the fat content. In such a case, a sample provides reliable information about the population; a census destroys the population and, with it, the need for information about it.

- Data can be collected more quickly, so estimates can be published in a timely fashion. An estimate of the unemployment rate for 1994 is not very helpful if it takes until 2004 to interview every household.

- Finally, and less well known, estimates based on sample surveys are often more accurate than those based on a census because investigators can be more careful when collecting data. A complete census often requires a large administrative organization and involves many persons in the data collection. With the administrative complexity and the pressure to produce timely estimates, many types of errors can be easily injected into the census. In a sample, more attention can be devoted to data quality through training personnel and following up on nonrespondents. It is far better to have good measurements on a representative sample than unreliable or biased measurements on the whole population.

Deming says, "Sampling is not mere substitution of a partial coverage or for a total coverage. Sampling is the science and art of controlling and measuring the reliability of useful statistical information through the theory of probability" (1950, 2).