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Title slide: Statistical Analysis of NCES Datasets Employing a Complex Sample Design

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This module will provide users with important information about statistical procedures and methods necessary for the proper analysis of NCES datasets that are based on complex sample survey designs. These procedures incorporate sampling weights as well as appropriate methods for calculating standard errors for various univariate and multivariate statistical techniques. This module also includes information about using selected statistical packages for these analyses along with examples.

The three objectives of this module are:

- To describe the major techniques for calculating estimates and their standard errors using NCES complex sample survey data;
- To explain and illustrate how these techniques are applied using selected software packages; and
- To present and explain selected techniques for univariate and multivariate statistical analyses of NCES data using appropriate survey weights and estimation methods for calculating standard errors.

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When analyzing data from a study with a complex sample design, a statistical analysis that assumes the data are drawn from a simple random sample tends to underestimate standard errors. Incorrect standard errors can lead to incorrect decisions about statistical significance when testing statistical estimates. This section of the module will first define standard errors. It will then explain the importance of standard errors and describe special methods for calculating them to reflect complex sample designs like those used in many NCES studies. Several specific methods will be explained.

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Every estimate calculated from a sample - such as a mean, a percentage, or a regression coefficient - has a standard error associated with it. All statistical analyses, such as hypothesis testing, calculation of confidence intervals, and modeling that use complex survey data require the calculation of standard errors using appropriate methods that account for the sampling design.

A standard error – or SE - is the standard deviation of an estimate's sampling distribution. For example, many samples could be drawn from a population to calculate a mean. The mean for one sample is likely to be different from the mean calculated for a different sample. The standard error of the mean indicates how much the mean would fluctuate from sample to sample, for multiple samples of the same size.

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Taking the standard error into consideration is very important to the analysis process because it indicates the level of precision associated with an estimate. That is, the standard error indicates how close the estimate generated from a sample is to the true population value. The relationship between the standard error and precision is an inverse one. A correctly computed smaller standard error indicates a more precise estimate.

Because an inaccurate standard error can lead to incorrect findings, it is very important to ensure that the standard error is being computed correctly.

- Type I Errors occur when an underestimated standard error leads to the inaccurate identification of a statistically significant result, where none is actually present.
- Type II Errors occur when an overestimated standard error leads to a failure to detect a significant finding when there is one.

Using the correct standard error will help reduce the chance of both Type I and Type II Errors.

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If one draws a Simple Random Sample, or SRS, of size ‘n’ from a population, meaning that every person has an equal chance of being selected into the sample, and calculates a mean for some variable ‘x’, then the standard error is the sample estimate of the population’s standard deviation, or sample standard deviation, divided by the square root of the sample size, assuming statistical independence of the values in the sample.

Calculating the standard error for an NCES study with a complex sampling design requires special procedures and formulas which are described in the next several slides.

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Most NCES sample survey datasets are derived from studies with complex sampling designs, rather than from studies with simple random samples. In complex sample survey designs, different subgroups of the sample frame members have different probabilities of being selected into the sample. Appropriate methods that account for the design must be used to calculate correct variances and standard errors.

Basic statistical software procedures calculate standard errors with the assumption that the data were collected from a simple random sample. As a result, they will tend to underestimate standard errors for estimates from complex sample surveys. To avoid this underestimation, methods that account for the complex survey design must be used to produce more accurate standard errors.

Two common approaches are replication techniques and Taylor series linearization.

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There are several statistical software packages that support variance estimation techniques for complex sample surveys, including those listed here. The survey-specific modules within the DLDT will provide details regarding how to appropriately calculate standard errors for your analytic purposes using the selected dataset.

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The replication method calculates appropriate standard errors based on differences between **estimates** from the full sample and a **series of subsamples or replicates** that are drawn from the full survey sample. There are two different types of replication techniques supported by NCES: **balance repeated** replicates, and **jackknife** replicates. These techniques compute estimates in different ways that are dictated by the survey design information included on data files.

The survey-specific modules within the DLDT will provide details regarding the replication techniques relevant for the dataset of interest using selected statistical software packages.

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Replicate weights are not employed when using Taylor Series linearization. Instead, this method uses variables provided in the dataset, such as identifiers for Primary Sampling Unit, or PSU, and strata, to produce a linear approximation for the estimate of interest, then the variance of the linear approximation is estimated using standard variance formulas.

It is important to note that Taylor Series is the only method for obtaining complex sampling variance estimates within the SPSS Statistics Core system. A bootstrapping add-on module is available for purchase to enable replication techniques for complex sample variance estimation procedures within SPSS.

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To see examples of how a statistic and its accompanying standard error might be obtained from an NCES dataset using both SRS and appropriate complex survey methods, press pause, and click the underlined screen text of the statistical software package you are most familiar with.

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Before you begin calculating appropriate standard errors and testing hypotheses, it is a good idea to get well acquainted with your dataset. You can do this by running basic descriptive statistics such as frequency counts, crosstabs, and percentage distributions. Crosstabs and correlation tables will also provide useful information. Running descriptive statistics will help to ensure that you have the appropriate number of cases in your sample, that you have enough cases to run your desired analysis, and that you have selected and recoded the data appropriately.

You should always use sampling weights when generating estimates and testing hypotheses, as NCES survey samples were not selected using simple random sampling.

All statistical tests conducted using data from NCES studies with complex sampling designs should be based on weighted data with standard errors that are calculated to account for the complex sample design. It is recommended that analysts use specialized software that computes more precise adjusted standard errors using replication or Taylor Series methods.

Remember - If you do not use appropriate variance estimation techniques, you will underestimate your variance. Therefore, your tests of statistical significance, confidence intervals, and modeling results will be incorrect. It may be useful to use NCES data tools, such as the NAEP Data Explorer or PowerStats, for your analysis as they automatically use appropriate methods to account for the variance.

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This module was designed to provide you with important information about statistical procedures and methods necessary for the proper analysis of NCES datasets that are based on complex sample survey designs. Understanding and using these procedures will allow you to properly analyze NCES survey data.

It is imperative that you use sampling weights as well as appropriate procedures for estimating standard errors for various univariate and multivariate techniques in order to ensure that you are producing correct estimates and accurate tests of statistical significance.

This module also included information about using selected statistical packages for these analyses along with examples and syntax for the demonstrated analyses in four statistical software packages. Users may also elect to assess their learning by answering multiple choice questions pertaining to this module through the Check Your Knowledge option located at the bottom of the screen. This is an optional tool that users may use at any time to review key concepts. To begin Check Your Knowledge, click the “Check Your Knowledge” button.

You may now proceed to the next module in the series, or click the exit button to return to the landing page.