#### Sampling Distribution

**CONCEPT** The probability distribution of a sample statistic for all possible samples of a given size nfor a given population.

#### Central Limit Theorem

**CONCEPT** The sampling distribution of the mean can be approximated by the normal distribution when the sample size of all possible samples gets large enough.

#### Sampling Distribution of the Proportion

**CONCEPT** The probability distribution of a proportion for all possible samples of a given size n for a given population.

#### Sampling Error

**CONCEPT** The variation that occurs due to selecting a single sample from the population.

* **Confidence Interval Estimate**

**CONCEPT** A range with an explicit lower and upper limit, stated with a specific degree of certainty, that represents an estimate of a population parameter.

* You must state the given degree of certainty, or **confidence**, when reporting an interval estimate, as in “interval estimate with 95% confidence," sometimes more simply phrased as a “95% confidence interval estimate.”

#### *t* Distribution

#### CONCEPT The sampling distribution that allows you to develop a confidence interval estimate of the mean using the sample standard deviation.

#### Confidence Interval Estimation for the Proportion

#### CONCEPT The sampling distribution of the proportion that allows you to develop a confidence interval estimate of the proportion using the sample proportion of successes, p. The sample statistic pfollows a binomial distribution that can be approximated by the normal distribution for most studies*.*

#### Bootstrapping

#### CONCEPT The confidence interval estimation methods that use repeated resampling with replacement of the initial sample being used as the basis of estimation.

* Use the confidence interval estimate for the mean for a numerical variable.
* Use the confidence interval estimate for the proportion for a categorical variable.

#### Null Hypothesis

#### CONCEPT The statement that a population parameter is equal to a specific value or that the population parameters from two or more groups are equal.

#### Alternative Hypothesis

**CONCEPT** The statement paired with a null hypothesis that is mutually exclusive to the null hypothesis.

#### Test Statistic

**CONCEPT** The value based on the sample statistic and the sampling distribution for the sample statistic.

#### The sampling distribution of the test statistic is divided into two regions, a [region of rejection](https://www.safaribooksonline.com/library/view/even-you-can/9780133382693/gloss01.html#gloss74) (also known as the critical region) and a region of non-rejection. If the test statistic falls into the region of nonrejection, the null hypothesis is not rejected.

#### Type I Error

**CONCEPT** The error that occurs if the null hypothesis H0 is rejected when it is true and should not be rejected.

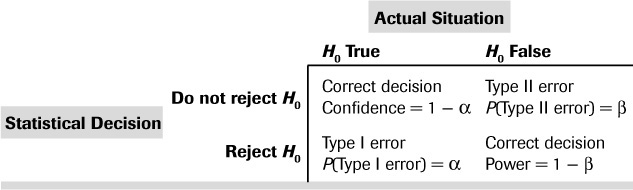
 The risk, or probability, of a type I error occurring is identified by the Greek lowercase alpha, α. Alpha is also known as the level of significance of the statistical test. Traditionally, you control the probability of a type I error by deciding the risk level α you are willing to tolerate of rejecting the null hypothesis when it is true. Because you specify the level of significance before performing the hypothesis test, the risk of committing a type I error, α, is directly under your control. The most common α values are 0.01, 0.05, and 0.10, and researchers traditionally select a value of 0.05 or smaller.

#### Type II Error

**CONCEPT** The error that occurs if the null hypothesis H0 is not rejected when it is false and should be rejected.

The risk, or probability, of a type II error occurring is identified by the Greek lowercase beta, β. The probability of a type II error depends on the size of the difference between the value of the population parameter stated in the null hypothesis and the actual population value. Unlike the type I error, the type II error is not directly established by you. Because large differences are easier to find, as the difference between the value of the population parameter stated in the null hypothesis and its corresponding population parameter increases, the probability of a type II error decreases. Therefore, if the difference between the value of the population parameter stated in the null hypothesis and the corresponding parameter is small, the probability of a type II error will be large.

The arithmetic complement of beta, 1 – β, is known as the **power of the test** and represents the probability of rejecting the null hypothesis when it is false and should be rejected.



* One way in which you can lower β without affecting the value of α is to increase sample size. Larger sample sizes generally permit you to detect even very small differences between the hypothesized and actual values of the population parameter. For a given level of α, increasing the sample size will decrease β and therefore increase the power of the test to detect that the null hypothesis *H*0 is false.

### PERFORMING HYPOTHESIS TESTING

When you perform a hypothesis test, you should follow the steps of hypothesis testing in this order:

1. State the null hypothesis, H0, and the alternative hypothesis, H1.

2. Evaluate the risks of making type I and II errors, and choose the level of significance, α, and the sample size as appropriate.

3. Determine the appropriate test statistic and sampling distribution to use and identify the critical values that divide the rejection and nonrejection regions.

4. Collect the data, calculate the appropriate test statistic, and determine whether the test statistic has fallen into the rejection or the nonrejection region.

5. Make the proper statistical inference. Reject the null hypothesis if the test statistic falls into the rejection region. Do not reject the null hypothesis if the test statistic falls into the nonrejection region.

#### p-Value

**CONCEPT** The probability of computing a test statistic equal to or more extreme than the sample results, given that the null hypothesis H0 is true.

The *p*-value is the smallest level at which *H*0 can be rejected for a given set of data. You can consider the *p*-value the actual risk of having a type I error for a given set of data. Using*p*-values, the decision rules for rejecting the null hypothesis are as follows:

• If the p-value is greater than or equal to α, do not reject the null hypothesis.

• If the p-value is less than α, reject the null hypothesis.

The *p*-value is also known as the **observed level of significance**.

When using *p*-values, you can restate the steps of hypothesis testing as follows:

1. State the null hypothesis, *H*0, and the alternative hypothesis, *H*1.

2. Evaluate the risks of making type I and II errors, and choose the level of significance, α, and the sample size as appropriate.

3. Collect the data and calculate the sample value of the appropriate test statistic.

4. Calculate the *p*-value based on the test statistic and compare the *p*-value to α.

5. Make the proper statistical inference. Reject the null hypothesis if the *p*-value is less than α. Do not reject the null hypothesis if the *p*-value is greater than or equal to α.

Your choice of which statistical test to use when performing hypothesis testing is influenced by the following factors:

• **Number of groups of data**: one, two, or more than two

• **Relationship stated in alternative hypothesis H1: not equal to or inequality** (less than, greater than)

You use a **two-tail test** for alternative hypotheses that use the not-equal sign and use a **one-tail test** for alternative hypotheses that contain an inequality.

• **Type of variable** (population parameter): numerical (mean) or categorical (proportion)

The type of variable, numerical or categorical, also influences the choice of hypothesis test used. For a numerical variable, the test might examine the population mean or the differences among the means, if two or more groups are used. For a categorical variable, the test might examine the population proportion or the differences among the population proportions if two or more groups are used

#### Pooled-Variance t Test

**CONCEPT** The hypothesis test for the difference between the population means of two independent groups that combines or “pools” the sample variance of each group into one estimate of the variance common in the two groups.

* For tests for the differences between two groups, first determine whether your data are categorical or numerical:

If your data are categorical, use the Z test for the difference between two proportions.

If your data are numerical, determine whether you have independent or related groups:

If you have independent groups, use the pooled variance t test for the difference between two means.

If you have related groups, use the paired t test.

### CHI-SQUARE TEST FOR TWO-WAY CROSS-CLASSIFICATION TABLES

**CONCEPT** The hypothesis tests for the difference in the proportion of successes in two or more groups or a relationship between two categorical variables in a two-way cross-classification table.

#### One-Way ANOVA

**CONCEPT** The hypothesis test that simultaneously compares the differences among the population means of more than two groups in a one-factor experiment.