**Lab 7**

**Hypothesis Testing**

1. What is hypothesis testing?

Hypothesis testing is the procedure that makes a decision to reject or to fail to reject a given null hypothesis. Normally, while the null hypothesis is the hypothesis that has existed before, the alternative hypothesis is the hypothesis that we would like to prove as true.

1. Hypothesis tests are always done under the assumption that the null hypothesis is true. They ask the question, “Is it likely that I would have observed my test statistic if the null hypothesis were true?” If it is likely, then do not reject the null hypothesis. If it is unlikely, then reject the null hypothesis.
2. Steps for Hypothesis Testing

1. State the hypotheses (both null and alternative)

2. Specify the significance level (α)

1. Draw sample of size *n* and compute the test statistic.
2. Calculate p-value. Compare p-value to the significance level. Reject H0 if *p*<α.

5. State conclusions in terms of subject matter

1. Normal tests (Z-tests)

* *Test statistic*: 
* *Distribution of Test Statistic*: Standard Normal

1. Types of Errors

1. Type I

- Type I error is when you reject H0 when H0 is true

- α ≡ P(reject H0 | H0 is true).

- Type I error is usually set by the investigator.

2. Type II

- Type II error is when you fail to reject Ho when Ho is false

- β ≡ P(do not reject H0 | H0 is not true).

1. P-value: The probability of getting a test statistic *as or more extreme* than the one observed given that the null hypothesis is true. Reject H0 if p<α.
2. Relationship between hypothesis testing and confidence intervals.
3. Hypothesis testing uses the observed data to determine how likely it would be for the sample statistic (e.g., the sample mean) to occur under the assumption that the hypothesized value is the truth.
4. Confidence intervals are intervals which contain values (which is fixed) which are plausible values for μ based on the data.
5. If the null value is in the confidence interval for normal data, you will not reject H0 if you perform a hypothesis test.

Confidence intervals: "We are 95% confident that this interval contains the population mean."

Hypothesis Testing: Do not reject the null hypothesis for any value of μ0 that is contained in the confidence interval.

1. Two-sided vs. one-sided hypothesis testing

1. Two-sided tests are more conservative.

2. The p-value for a two-sided test is usually twice that of a one-sided test.

1. A one-sided test achieves significance sooner. (making such tests controversial)

**Example**

1. Consider the distribution of heights for the population of 12-40 year-olds who suffer from fetal alcohol syndrome. Recall that this distribution is approximately normal with unknown mean μ and known standard deviation σ=6 cm. Suppose you want to know whether the mean height for this population is equal to the mean height for individuals in the same age group who do not have fetal alcohol syndrome, which you know to be 160.0 cm. Your sample of size 31 drawn from this population had a mean height of =147.4 cm. Perform an appropriate hypothesis test at the =0.05 level of significance.

* State the null hypothesis.

The mean of height for the population of 12-40 years olds suffering from fetal alcohol syndrome is the same to that of height for the population of the same age group not suffering from fetal alcohol syndrome. ()

* State the alternative hypothesis.

The mean of height for the population of 12-40 years olds suffering from fetal alcohol syndrome is not the same to that of height for the population of the same age group not suffering from fetal alcohol syndrome. ()

* Is a one-sided or two-sided test more appropriate? Why?

Two sided test is more appropriate since the mean of height for the population of 12-40 years olds suffering from fetal alcohol syndrome might be smaller or larger than height of nonaffected individuals.

* If the null hypothesis is indeed true, what is the probability that you will incorrectly reject it?

The probability for incorrectly rejecting it is

* Calculate and interpret your test statistic. What is the distribution of the test statistic

== -11.599509,

. di (31^0.5)\*(147.5-160)/6

* Do you reject or not reject the null hypothesis?

We reject the null hypothesis since the test statistic -11.599509 is less than -1.96.

* Calculate the p-value of your test statistic and interpret your p-value.

+1.231e-30

di 2\*normal(-11.506)

* What is your conclusion?

We conclude that the mean of height for the population of 12-40 years olds suffering from fetal alcohol syndrome is not the same to that of height for the population of the same age group not suffering from fetal alcohol syndrome.

* How could you use the confidence interval calculated in the previous section to answer the question of interest? What is one piece of information that hypothesis testing gives which confidence intervals do not?

95% CI for it is [145.29, 149.51]. It does not contain the mean 160. Thus, we can conclude in the same way. (rejecting null hypothesis)

di 147.4- (6/31^0.5)\*invnormal(0.975)

145.28788

di 147.4 + (6/31^0.5)\*invnormal(0.975)

149.51212

ADD: do the same test but assume the standard deviation is only an estimate and use the t distribution instead

2. Suppose you are interested in testing whether the mean benzene concentration in cigars is the same as in cigarettes. You know that the mean concentration of benzene in cigarettes is 81 mg/g tobacco but you don’t know the mean concentration in cigars. However, you find that a random sample of seven cigars has a mean benzene concentration of =151 mg/g. Assume the distribution of benzene in cigars is approximately normal with known standard deviation of σ=9g/g. Perform an appropriate hypothesis test at the 0.05 level of significance.

* State the null hypothesis.

The mean concentration of benzene in cigars is the same to that of benzene in cigarettes. ()

* State the alternative hypothesis.

The mean concentration of benzene in cigars is not the same to that of benzene in cigarettes. ()

* Is a one-sided or two-sided test more appropriate?

Two sided test would be appropriate since the mean concentration of benzene in cigars might be different from cigarettes in a smaller or larger cases.

* Calculate your test statistic. What is the distribution of your test statistic?

== 20.578066 ,

di (7^0.5)\*(151-81)/9

* Do you reject or not reject the null hypothesis?

We reject the null hypothesis since the test statistics 20.578066 is greater than 1.96.

* Calculate and interpret the p-value of your test statistic.

+1.231e-30

di 2\*normal()

* What is your conclusion?

The mean concentration of benzene in cigars is not the same to that of benzene in cigarettes. ()