Chapter 10: Hypothesis Testing - Two Samples

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Introduction

- Previously we were testing if the mean is equal to a number
- Now we test if two groups have the same mean

Why test two means?

- Test differences between two different sets of people (or any two sets).
- Test differences on certain issue between control and experimental group.

Null and Alternaive Hypothesis

- Null Hypothesis is
  $H_0 : \mu_1 = \mu_2$
- Alternative Hypothesis is
  $H_1 : \mu_1 \neq \mu_2$

Can have $<$, $>$, or $\neq$ is alternative.

Outline

- 2 - Sample Z test. (means when both σ known)
- 2 - Sample T test. (means when one σ is unknown or both s is known)
- 2-Prop Z test (proportions)

Outline

One more:

- Paired data we use a T-test

Central Limit Theorem

The machinery is still the Central Limit Theorem

. . . But it is more complicated since we have two means.

$$\mu_1 - \mu_2 = 0$$

Standard Deviation

New Standard Deviation for averages is

$$\sqrt{\frac{\sigma_1^2}{n} + \frac{\sigma_2^2}{n}}$$

Standard Deviation

- New Standard Deviation for proportion is

$$\sqrt{\frac{p_1 q_1}{n} + \frac{p_2 q_2}{n}}$$

Pooled vs Unpooled

- We can have pooled (same variances) or unpooled (different variances) data
- We use unpooled

Example 1

- A researcher wishes to compare Body Mass Index(BMI) for two different racial groups within the U.S. at ages from 20-39. The CDC gathered data and the results of their study are below. At the $\alpha = .01$ level, is there enough evidence to reject the claim that the average BMI of both groups is the same?

Non Hispanic Black BMI	Hispanic BMI
$\overline{X_1} = 28.4$	$\overline{X_2} = 29.3$
$S_1 = 6.35$	$S_2 = 5.60$
$n_1 = 404$	$n_2 = 385$

Solution

Example 2

- A person claims that the arm length of men is longer than the arm length of women on average. The CDC studied upper arm length of males and females between the ages of 20 and 29. Their data is shown in centimeters. Test the claim that men have an average upper arm length which is longer than women. Use $\alpha = .05$.

Men arm length	Women arm length
$\overline{X_1} = 38.9$	$\overline{X_2} = 35.7$
$S_1 = 2.15$	$S_2 = 1.95$
$n_1 = 918$	$n_2 = 891$

Solution

Example 3

- A lawyer claims that there is no difference between the pay of professors at Central Michigan University (CMU) and professors at Western Michigan University (WMU). A survey of 284 professors at CMU showed an average salary of \$108,500. A survey of 357 professors at WMU found an average salary of \$109,600. If we assume that the population standard deviation in each case was \$22,000, is the lawyer correct? Use $\alpha = .05$.

Solution

Example 4

- A survey of 500 professors at 2-year colleges in Michigan showed an average salary of \$79,083 with a sample standard deviation of \$21,560. A survey of 35 professors at Mid Michigan College showed an average salary of \$63,956 with a sample standard deviation of \$15,170. Can we conclude that average professor salary at Mid Michigan College is below the Michigan average? Use $\alpha = .05$.

Solution

Example 5

- The NASS records crop yields per acre in Michigan. In 2017, a sample of 28 counties in North and Central Michigan had an average of 142.98 bushels per acre of corn with a sample standard deviation of 22.71. Also that year, a sample of 27 counties in Southern Michigan had an average corn production of 158.01 bushels per acre with a sample standard deviation of 16.26. At $\alpha = .02$, are the southern counties producing more corn per acre than the northern counties?

Solution

Example 6

- A health care worker wishes to see if the average number of family day care homes is greater than the average number of day care centers per county. The number of centers for a selected number of counties is shown. At , can it be concluded that the average number of family day care homes is greater than the average number of day care centers.

No. of family day care homes	25	56	34	42	21	44

No. of day care centers	16	14	5	28	37	48	20	22

Solution

Example 7

- As an aid for improving students' study habits, nine students were randomly selected to attend a seminar on the importance of educational life. The table shows the number of hours each student studied per week before and after the seminar. At $\alpha = .10$, did attending the seminar increase the number of hours the students studied per week?

Before	9	12	6	15	3	18	10	13	7
After	9	17	9	20	2	21	15	22	6

Solution

Example 8

- A study was conducted to investigate the effectiveness of hypnotism in reducing pain. Results for randomly selected subjects are shown in the table. A lower score indicates less pain. The differences are normally distributed. Are the sensory measurements, on average, lower after hypnotism? Test at a 5% significance level.

	A	B	C	D	E	F	G	H
Before	6.6	6.5	9.0	10.3	11.3	8.1	6.3	11.6
After	6.8	2.4	7.4	8.5	8.1	6.1	3.4	2.0

Solution

Example 9

- In 2017, a sample of 357 males from the "Boomers" generation showed that 75 had been veterans. A sample of 700 males from the "Millennials" generation showed that 28 had been veterans. Is there a significant difference in the proportions? Use $\alpha = .05$.

Solution

Example 10

- Pew research did a survey in 2018 looking at the numbers of parent who are "solo parents" (meaning raising their children alone). Among a sample of 644 "solo" fathers, 161 were classified as being white. Among a sample of 763 "solo" mothers, 183 were classified as being white. Is there a significant difference in the proportions of each group which was classified as being white? Use $\alpha = .10$.

Solution

Example 11

- In a sample of 800 U.S. adults, 44% said they trusted people from holistic or alternative health groups when talking about vaccines. In the same sample, 49% said they trust pharmaceutical industry leaders when talking about vaccines. At $\alpha = .05$, does a lower percentage of U.S. adults trust holistic groups than pharmaceutical leaders when talking about vaccines?

Solution