Bunker Hill Community College

Final Statistics Exam 2019-05-02 Exam ID 006

Name: ______________________________

This take-home exam is due **Wednesday, May 8**, at the beginning of class.

You may use any notes, textbook, or online tools; however, you may not request help from any other human.

You will show your work on the pages with questions. When you are sure of your answers, you will **put those answers in the boxes** on the first few pages.

Unless you have an objection to doing so, please **copy the honor-code text below and sign**.

I understand that outside help is NOT allowed on this exam. On my honor, the work herein is my own.

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Signature: ______________________________

1. (a) $P($**shovel**$) = 0.247$

   (b) $P($**gray given bike**$) = 0.311$

   (c) $P($**gem and orange**$) = 0.0291$

   (d) $P($**bike given yellow**$) = 0.239$

   (e) $P($**gem or violet**$) = 0.444$

   (f) $P($**violet**$) = 0.258$

2. $P($**"not shovel" given "not blue"**$) = 0.777$

3. $P(69.04 < X < 69.24) = 0.6538$

4. (a) $P(X = 59) = 0.0411$

   (b) $P(70 \leq X \leq 76) = 0.1751$

5. **(12.5, 13.2)**

6. (a) $H_0 : \quad \mu_2 - \mu_1 = 0$

   (b) $H_0 : \quad \mu_2 - \mu_1 \neq 0$

   (c) $t^{\star} = 1.72$

   (d) $SE = 0.489$

   (e) $\mid t_{\textbf{obs}} \mid = 1.43$

   (f) $0.1 <$ p**-value** < 0.2

   (g) **retain**

7. (a) **LB of p CI = 0.715 or** 71.5%

   (b) **UB of p CI = 0.743 or** 74.3%

8. (a) $H_0: \ p_2 - p_1 = 0$

(b) $H_\mathbf{A}: \ p_2 - p_1 \neq 0$

(c) $z^\star = 1.28$

(d) $SE = 0.038$

(e) $\mid z_{\mathbf{obs}} \mid = 1.39$

(f) p-**value** = 0.1646

(g) **reject**

1. In a deck of strange cards, there are 928 cards. Each card has an image and a color. The amounts are shown in the table below.

	gray	orange	violet	yellow
bike	79	86	37	52
cat	50	53	69	54
gem	56	27	46	90
shovel	61	59	87	22

(a) What is the probability a random card is a shovel?

(b) What is the probability a random card is gray given it is a bike?

(c) What is the probability a random card is both a gem and orange?

(d) What is the probability a random card is a bike given it is yellow?

(e) What is the probability a random card is either a gem or violet (or both)?

(f) What is the probability a random card is violet?

Solution

(a) $P(\text{shovel}) = \frac{61+59+87+22}{928} = 0.247$

(b) $P(\text{gray given bike}) = \frac{79}{79+86+37+52} = 0.311$

(c) $P(\text{gem and orange}) = \frac{27}{928} = 0.0291$

(d) $P(\text{bike given yellow}) = \frac{52}{52+54+90+22} = 0.239$

(e) $P(\text{gem or violet}) = \frac{56+27+46+90+37+69+46+87-46}{928} = 0.444$

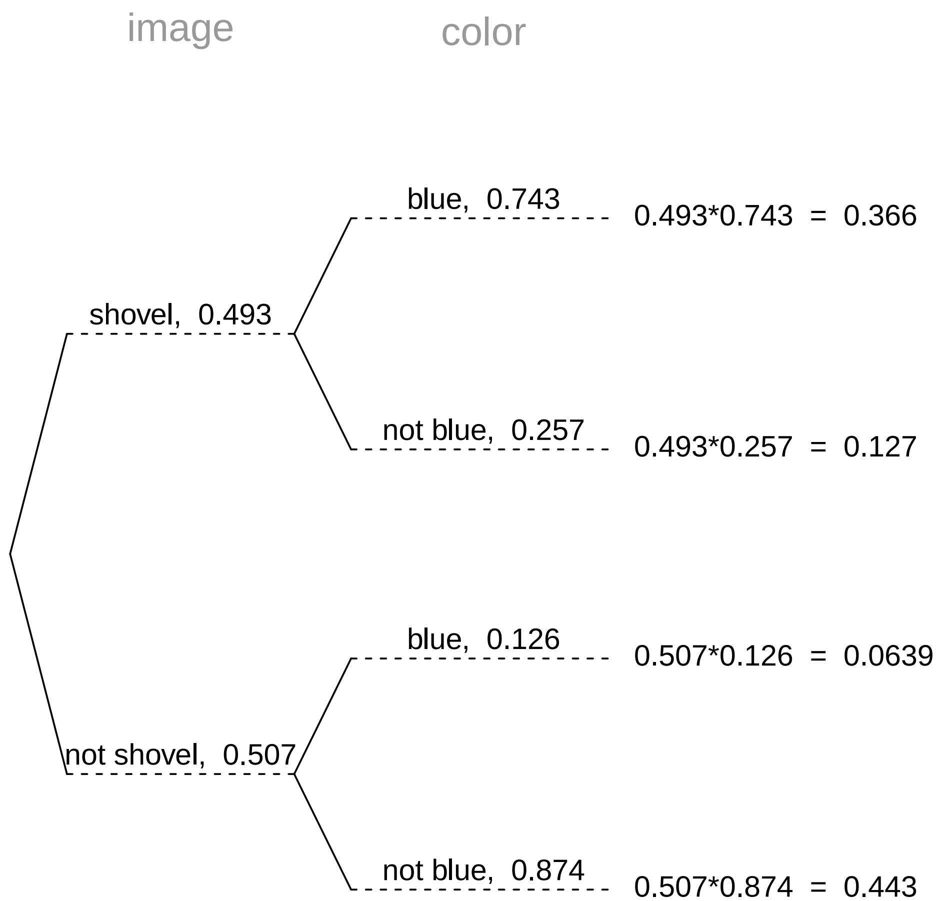
(f) $P(\text{violet}) = \frac{37+69+46+87}{928} = 0.258$

2. In a deck of strange cards, each card has an image and a color. The chance of drawing a shovel is 49.3%. If a shovel is drawn, there is a 74.3% chance that it is blue. If a card that is not a shovel is drawn, there is a 12.6% chance that it is blue.

   Now, someone draws a random card and reveals it is not blue. What is the chance the card is not a shovel?

Solution

I'd recommend making a tree. Remember, on the first branch, we put simple probabilities. On the second branches we put conditional probabilites. The results (products) are joint probabilities.



Determine the appropriate conditional probability.

$$P(\text{"not shovel" given "not blue"}) = \frac{0.443}{0.443 + 0.127} = 0.777$$

3. In a very large pile of toothpicks, the mean length is 69.19 millimeters and the standard deviation is 1.01 millimeters. If you randomly sample 120 toothpicks, what is the chance the sample mean is between 69.04 and 69.24 millimeters?

Solution

Label the given information.

$$\mu = 69.19$$
$$\sigma = 1.01$$
$$n = 120$$
$$\bar{x}_{\text{lower}} = 69.04$$
$$\bar{x}_{\text{upper}} = 69.24$$

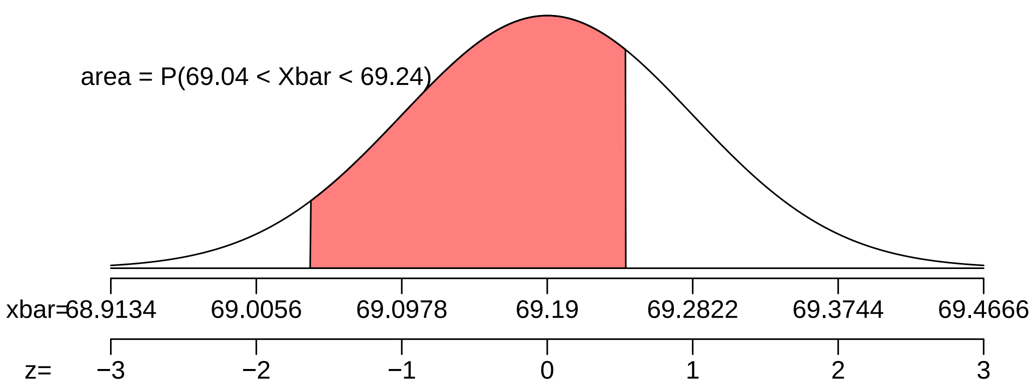
Find the standard error.

$$SE = \frac{\sigma}{\sqrt{n}} = \frac{1.01}{\sqrt{120}} = 0.0922$$

Describe the sampling distribution.

$$\bar{X} \sim \mathcal{N}(69.19,\ 0.0922)$$

Draw a sketch.



Calculate a z scores.

$$z_{\text{lower}} = \frac{x_{\text{lower}} - \mu}{SE} = \frac{69.04 - 69.19}{0.0922} = -1.63$$

$$z_{\text{upper}} = \frac{x_{\text{upper}} - \mu}{SE} = \frac{69.24 - 69.19}{0.0922} = 0.54$$

Determine the probability.

$$\begin{aligned} P(69.04 < X < 69.24) &= \Phi(z_{\text{upper}}) - \Phi(z_{\text{lower}}) \\ &= \Phi(0.54) - \Phi(-1.63) \\ &= 0.6538 \end{aligned}$$

4. In a game, there is a 34% chance to win a round. You will play 191 rounds.
   (a) What is the probability of winning exactly 59 rounds?
   (b) What is the probability of winning at least 70 but at most 76 rounds?

Solution

We use the formula for binomial probabilities.

$$P(X = k) = \binom{n}{k}(p)^k(1-p)^{n-k}$$

$$P(X = 59) = \binom{191}{59}(0.34)^{59}(1-0.34)^{191-59}$$

$$P(X = 59) = \binom{191}{59}(0.34)^{59}(0.66)^{132}$$

$$P(X = 59) = 0.0411$$

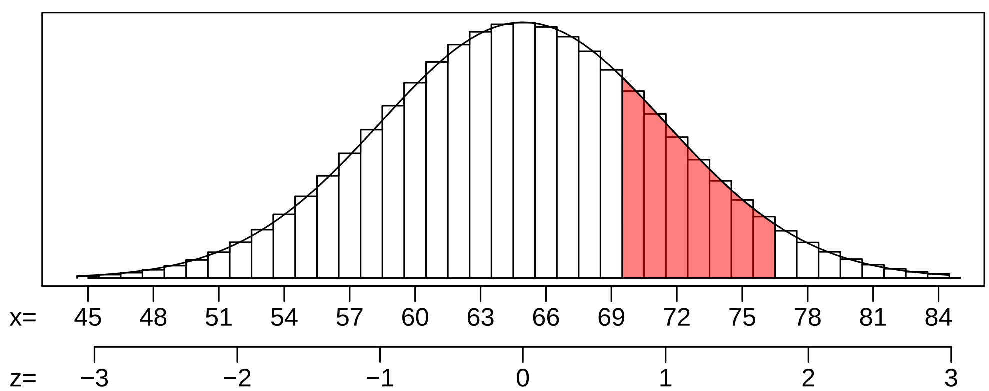
Find the mean.

$$\mu = np = (191)(0.34) = 64.94$$

Find the standard deviation.

$$\sigma = \sqrt{np(1-p)} = \sqrt{(191)(0.34)(1-0.34)} = 6.5468$$

Make a sketch, specifically try to picture whether you need to add or subtract 0.5 for the continuity correction.



Find the z scores.

$$z_1 = \frac{69.5 - 64.94}{6.5468} = 0.77$$

$$z_2 = \frac{76.5 - 64.94}{6.5468} = 1.69$$

Calculate the probability.

$$P(70 \leq X \leq 76) = \Phi(1.69) - \Phi(0.77) = 0.1751$$

(a) $P(X = 59) = 0.0411$

(b) $P(70 \leq X \leq 76) = 0.1751$

5. As an ornithologist, you wish to determine the average body mass of *Vermivora peregrina*. You randomly sample 35 adults of *Vermivora peregrina*, resulting in a sample mean of 12.82 grams and a sample standard deviation of 1.26 grams. Determine a 90% confidence interval of the true population mean.

Solution

We are given the sample size, sample mean, sample standard deviation, and confidence level.

$$n = 35$$
$$\bar{x} = 12.82$$
$$s = 1.26$$
$$CL = 0.9$$

Determine the degrees of freedom (because we don't know σ and we are doing inference so we need to use the t distribution).

$$df = n - 1 = 34$$

Determine the critical t value, $t^\star$, such that $P(|T| < t^\star) = 0.9$.

$$t^\star = 1.69$$

Calculate the standard error.

$$SE = \frac{s}{\sqrt{n}} = \frac{1.26}{\sqrt{35}} = 0.213$$

We want to make an inference about the population mean.

$$\mu \approx \bar{x} \pm t^\star SE$$

Determine the bounds.

$$\begin{aligned} CI &= (\bar{x} - t^\star SE,\ \bar{x} + t^\star SE) \\ &= (12.82 - 1.69 \times 0.213,\ 12.82 + 1.69 \times 0.213) \\ &= (12.5,\ 13.2) \end{aligned}$$

We are 90% confident that the population mean is between 12.5 and 13.2.

6. A treatment group of size 17 has a mean of 10.5 and standard deviation of 1.04. A control group of size 13 has a mean of 11.2 and standard deviation of 1.51. If you decided to use a signficance level of 0.1, is there sufficient evidence to conclude the treatment causes an effect?

   By using the Welch-Satterthwaite equation, I've calculated the degrees of freedom should be 20.

   (a) State the null hypothesis.

   (b) State the alternative hypothesis.

   (c) Evaluate the critical value. (The critical value is either $z^\star$ or $t^\star$. Determine its value.)

   (d) Determine the standard error of the relevant sampling distribution.

   (e) Evaluate the absolute value of the test statistic. (The test statistic is either z_{obs} or t_{obs}. Determine its absolute value.)

   (f) If possible, evaluate the p-value. Otherwise, describe an interval containing the p-value.

   (g) Do we reject or retain the null?

Solution

We are given unpaired data. We are considering a difference of means. Label the given information.

$$n_1 = 17$$
$$\bar{x}_1 = 10.5$$
$$s_1 = 1.04$$
$$n_2 = 13$$
$$\bar{x}_2 = 11.2$$
$$s_2 = 1.51$$
$$\alpha = 0.1$$
$$df = 20$$

State the hypotheses.

$$H_0 : \quad \mu_2 - \mu_1 = 0$$
$$H_A : \quad \mu_2 - \mu_1 \neq 0$$

We are using a two-tail test. Find $t^\star$ such that $P(|T| > t^\star) = 0.1$ by using a t table.

$$t^\star = 1.72$$

Calculate the standard error.

$$\begin{aligned} SE &= \sqrt{\frac{(s_1)^2}{n_1} + \frac{(s_2)^2}{n_2}} \\ &= \sqrt{\frac{(1.04)^2}{17} + \frac{(1.51)^2}{13}} \\ &= 0.489 \end{aligned}$$

Determine the test statistic.

$$\begin{aligned} t_{\text{obs}} &= \frac{(\bar{x}_2 - \bar{x}_1) - (\mu_2 - \mu_1)_0}{SE} \\ &= \frac{(11.2 - 10.5) - (0)}{0.489} \\ &= 1.43 \end{aligned}$$

Compare $|t_{\text{obs}}|$ and $t^\star$.

$$|t_{\text{obs}}| < t^\star$$

We can determine an interval for the p-value using the t table.

$$0.1 < p\text{-value} < 0.2$$

Compare p-value and α.

$$p\text{-value} > \alpha$$

We conclude that we should retain the null hypothesis.

(a) $H_0 : \quad \mu_2 - \mu_1 = 0$

(b) $H_A: \mu_2 - \mu_1 \neq 0$

(c) $t^\star = 1.72$

(d) $SE = 0.489$

(e) $|t_{obs}| = 1.43$

(f) $0.1 < p\text{-value} < 0.2$

(g) retain the null

7. From a very large population, a random sample of 3800 individuals was taken. In that sample, 72.9% were super. Determine a 95% confidence interval of the population proportion.

   (a) Find the lower bound of the confidence interval.

   (b) Find the upper bound of the condifence interval.

Solution

Determine $z^{\star}$ such that $P(|Z| < z^{\star}) = 0.95$.

$$z^{\star} = 1.96$$

Calculate the standard error.

$$SE = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}} = \sqrt{\frac{(0.729)(1-0.729)}{3800}} = 0.00721$$

Calculate the margin of error.

$$ME = z^{\star} SE = (1.96)(0.00721) = 0.0141$$

To find the confidence interval's bounds, find the sample proportion plus or minus the margin of error.

$$p \approx \hat{p} \pm ME$$

Determine the interval.

$$(0.715\,,\ 0.743)$$

We are 95% confident that the true population proportion is between 71.5% and 74.3%.

(a) The lower bound = 0.715, which can also be expressed as 71.5%.

(b) The upper bound = 0.743, which can also be expressed as 74.3%.

8. An experiment is run with a treatment group of size 167 and a control group of size 135. The results are summarized in the table below.

	treatment	control
omnivorous	16	20
not omnivorous	151	115

Using a significance level of 0.2, determine whether the treatment causes an effect on the proportion of cases that are omnivorous.

(a) State the null hypothesis.

(b) State the alternative hypothesis.

(c) Evaluate the critical value. (The critical value is either $z^{\star}$ or $t^{\star}$. Determine its value.)

(d) Determine the standard error of the relevant sampling distribution.

(e) Evaluate the absolute value of the test statistic. (The test statistic is either z_{obs} or t_{obs}. Determine its absolute value.)

(f) If possible, evaluate the p-value. Otherwise, describe an interval containing the p-value.

(g) Do we reject or retain the null?

Solution

State the hypotheses.

$$H_0: \quad p_2 - p_1 = 0$$
$$H_A: \quad p_2 - p_1 \neq 0$$

Find $z^\star$ such that $P(|Z| > z^\star) = 0.2$.

$$z^\star = \Phi^{-1}\left(1 - \frac{\alpha}{2}\right) = 1.28$$

Determine the sample proportions.

$$\hat{p}_1 = \frac{16}{167} = 0.0958$$
$$\hat{p}_2 = \frac{20}{135} = 0.148$$

Determine the difference of sample proportions.

$$\hat{p}_2 - \hat{p}_1 = 0.148 - 0.0958 = 0.0522$$

Determine the pooled proportion (because the null assumes the population proportions are equal).

$$\hat{p} = \frac{16 + 20}{167 + 135} = 0.119$$

Determine the standard error.

$$\begin{aligned} SE &= \sqrt{\frac{\hat{p}(1-\hat{p})}{n_1} + \frac{\hat{p}(1-\hat{p})}{n_2}} \\ &= \sqrt{\frac{(0.119)(0.881)}{167} + \frac{(0.119)(0.881)}{135}} \\ &= 0.0375 \end{aligned}$$

We can be more specific about what the null hypothesis claims.

$$H_0: \quad \hat{P}_2 - \hat{P}_1 \sim \mathcal{N}(0,\ 0.0375)$$

We want to describe how unusual our observation is under the null by finding the p-value. To do so, first find the z score.

$$\begin{aligned} z &= \frac{(\hat{p}_2 - \hat{p}_1) - (p_2 - p_1)_0}{SE} \\ &= \frac{(0.148 - 0.0958) - 0}{0.0375} \\ &= 1.39 \end{aligned}$$

Determine the p-value.

$$\begin{aligned} p\text{-value} &= 2 \cdot \Phi(-|z|) \\ &= 2 \cdot \Phi(-1.39) \\ &= 0.1646 \end{aligned}$$

Compare the p-value to the signficance level.

$$p\text{-value} < \alpha$$

So, we reject the null hypothesis. Thus the difference in proportions is significant.

(a) $H_0: \quad p_2 - p_1 = 0$
(b) $H_A: \quad p_2 - p_1 \neq 0$
(c) $z^\star = 1.28$
(d) $SE = 0.0375$
(e) $|z_{\text{obs}}| = 1.39$
(f) p-value = 0.1646
(g) reject the null