Advanced Statistics
DS2003 (BDS-4A)
Lecture 09

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Previous Lecture

- Hypothesis Testing Framework
- Choosing a significance level
- Case of Type-1 and Type-2 errors being costly

Inference for a Single Proportion (Continued)

- Inference on a proportion

CI vs. HT for proportions

Success-failure condition:

- CI: At least 10 *observed* successes and failures
- HT: At least 10 *expected* successes and failures, calculated using the null value

Standard error:

- CI: calculate using observed sample proportion:

$$SE = \sqrt{\frac{p(1-p)}{n}}$$

- HT: calculate using the null value:

$$SE = \sqrt{\frac{p_0(1-p_0)}{n}}$$

Practice

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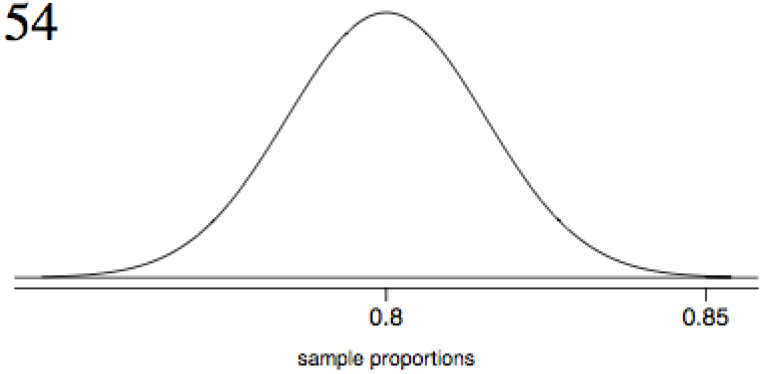

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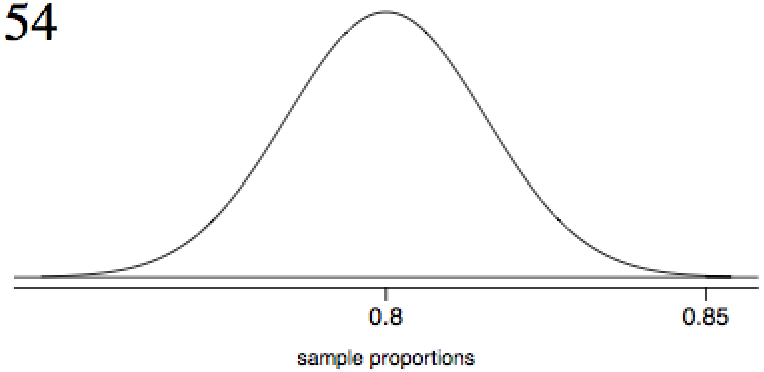
$$\begin{aligned} SE &= \sqrt{\frac{0.80 \times 0.20}{670}} = 0.0154 \\ Z &= \frac{0.85 - 0.80}{0.0154} = 3.25 \\ p-value &= 1 - 0.9994 = 0.0006 \end{aligned}$$



Since the p-value is low, we reject H_0. The data provide convincing evidence that more than 80% of Americans have a good intuition on experimental design.

Difference of Two Proportions

Melting ice cap

Scientists predict that global warming may have big effects on the polar regions within the next 100 years. One of the possible effects is that the northern ice cap may completely melt. Would this bother you a great deal, some, a little, or not at all if it actually happened?

(a) A great deal
(b) Some
(c) A little
(d) Not at all

Results from the GSS

The GSS asks the same question, below are the distributions of responses from the 2010 GSS as well as from a group of introductory statistics students at Duke University:

	GSS	Duke
A great deal	454	69
Some	124	30
A little	52	4
Not at all	50	2
Total	680	105

GSS -> website: [GSS General Social Survey | NORC]

Parameter and point estimate

- *Parameter of interest*: Difference between the proportions of *all* Duke students and *all* Americans who would be bothered a great deal by the northern ice cap completely melting.

$$p_{Duke} - p_{US}$$

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- *Point estimate*: Difference between the proportions of *sampled* Duke students and *sampled* Americans who would be bothered a great deal by the northern ice cap completely melting.

$$\hat{p}_{Duke} - \hat{p}_{US}$$

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Standard error of the difference between two sample proportions

$$SE_{(\hat{p}_1-\hat{p}_2)} = \sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}$$

Conditions for CI for difference of proportions

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2. *Independence between groups:*

   The sampled Duke students and the US residents are independent of each other.

3. *Success-failure:*

   At least 10 observed successes and 10 observed failures in the two groups.

Sample proportions are also nearly normally distributed

Construct a 95% confidence interval for the difference between the proportions of Duke students and Americans who would be bothered a great deal by the melting of the northern ice cap (p_{Duke} - p_{US}).

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$$= -0.011 \pm 0.097$$

$$= (-0.108, 0.086)$$

Practice

Which of the following is the correct set of hypotheses for testing if the proportion of all Duke students who would be bothered a great deal by the melting of the northern ice cap differs from the proportion of all Americans who do?

(a) $H_0 : p_{Duke} = p_{US}$
$H_A : p_{Duke} \neq p_{US}$

(b) $H_0 : \hat{p}_{Duke} = \hat{p}_{US}$
$H_A : \hat{p}_{Duke} \neq \hat{p}_{US}$

(c) $H_0 : p_{Duke} - p_{US} = 0$
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(d) $H_0 : p_{Duke} = p_{US}$
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Both (a) and (c) are correct.

Flashback to working with one proportion

- When constructing a confidence interval for a population proportion, we check if the *observed* number of successes and failures are at least 10.

$$n\hat{p} \geq 10 \qquad\qquad n * (1 - \hat{p}) \geq 10$$

- When conducting a hypothesis test for a population proportion, we check if the *expected* number of successes and failures are at least 10.

$$np_0 \geq 10 \qquad\qquad n * (1 - p_0) \geq 10$$

Pooled estimate of a proportion

- In the case of comparing two proportions where H_0: $p_1 = p_2$, there isn't a given null value we can use to calculated the *expected* number of successes and failures in each sample.

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- Therefore, we need to first find a common (*pooled*) proportion for the two groups, and use that in our analysis.
- This simply means finding the proportion of total successes among the total number of observations.

Pooled estimate of a proportion

$$\hat{p} = \frac{\#\ of\ successes_1 + \#\ of\ successes_2}{n_1 + n_2}$$

Practice

Calculate the estimated pooled proportion of Duke students and Americans who would be bothered a great deal by the melting of the northern ice cap. Which sample proportion ($\hat{p}_{Duke}$ *or* $\hat{p}_{US}$) the pooled estimate is closer to? Why?

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Do these data suggest that the proportion of all Duke students who would be bothered a great deal by the melting of the northern ice cap differs from the proportion of all Americans who do? Calculate the test statistic, the p-value, and interpret your conclusion in context of the data.

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$$p - value = 2 \times P(Z < -0.22) = 2 \times 0.41 = 0.82$$

Conclusion

- The p-value is 0.82
- We cannot reject H_0, therefore we say that we don’t have enough evidence to reject the notion that $p_{DUKE} = p_{US}$

- If the p-value would have been less than 0.05, we would have concluded that there is compelling evidence, or statistically significant results to indicate that we may reject H_0

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  - at least 10 successes and failures in each group
    - if not → randomization (Section 6.4)

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$$SE_{(\hat{p}_1 - \hat{p}_2)} = \sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}$$

- for CI: use $\hat{p}_1$ and $\hat{p}_2$
- for HT:
    - when H_0: $p_1 = p_2$: use $\hat{p}_{pool} = \frac{\#\ suc_1 + \#suc_2}{n_1 + n_2}$
    - when H_0: $p_1 - p_2$ = (some value other than 0): use $\hat{p}_1$ and $\hat{p}_2$
      - this is pretty rare

Reference - standard error calculations

	one sample	two samples
mean	$SE = \frac{s}{\sqrt{n}}$	$SE = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}$
proportion	$SE = \sqrt{\frac{p(1-p)}{n}}$	$SE = \sqrt{\frac{p_1(1-p_1)}{n_1} + \frac{p_2(1-p_2)}{n_2}}$

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- When working with means, it's very rare that σ is known, so we usually use *s*.
- When working with proportions,
  - if doing a hypothesis test, *p* comes from the null hypothesis
  - if constructing a confidence interval, use $\hat{p}$ instead

Sources

- openintro.org/os (Chapter 6)
- Recommended Viewing:
  - An Introduction to Inference for Two Proportions - YouTube