



Practice Exercises: Lesson 3.3

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STAT 1201
Introduction to Probability and Statistics

ONLINE AND DISTANCE EDUCATION

Exercises

5.15 Identify hypotheses, Part I. Write the null and alternative hypotheses in words and then symbols for each of the following situations.

- A tutoring company would like to understand if most students tend to improve their grades (or not) after they use their services. They sample 200 of the students who used their service in the past year and ask them if their grades have improved or declined from the previous year.
- Employers at a firm are worried about the effect of March Madness, a basketball championship held each spring in the US, on employee productivity. They estimate that on a regular business day employees spend on average 15 minutes of company time checking personal email, making personal phone calls, etc. They also collect data on how much company time employees spend on such non-business activities during March Madness. They want to determine if these data provide convincing evidence that employee productivity changed during March Madness.

5.16 Identify hypotheses, Part II. Write the null and alternative hypotheses in words and using symbols for each of the following situations.

- Since 2008, chain restaurants in California have been required to display calorie counts of each menu item. Prior to menus displaying calorie counts, the average calorie intake of diners at a restaurant was 1100 calories. After calorie counts started to be displayed on menus, a nutritionist collected data on the number of calories consumed at this restaurant from a random sample of diners. Do these data provide convincing evidence of a difference in the average calorie intake of a diners at this restaurant?
- The state of Wisconsin would like to understand the fraction of its adult residents that consumed alcohol in the last year, specifically if the rate is different from the national rate of 70%. To help them answer this question, they conduct a random sample of 852 residents and ask them about their alcohol consumption.

5.17 Online communication. A study suggests that 60% of college student spend 10 or more hours per week communicating with others online. You believe that this is incorrect and decide to collect your own sample for a hypothesis test. You randomly sample 160 students from your dorm and find that 70% spent 10 or more hours a week communicating with others online. A friend of yours, who offers to help you with the hypothesis test, comes up with the following set of hypotheses. Indicate any errors you see.

$$H_0 : \hat{p} < 0.6$$

$$H_A : \hat{p} > 0.7$$

5.18 Married at 25. A study suggests that the 25% of 25 year olds have gotten married. You believe that this is incorrect and decide to collect your own sample for a hypothesis test. From a random sample of 25 year olds in census data with size 776, you find that 24% of them are married. A friend of yours offers to help you with setting up the hypothesis test and comes up with the following hypotheses. Indicate any errors you see.

$$H_0 : \hat{p} = 0.24$$

$$H_A : \hat{p} \neq 0.24$$

5.19 Cyberbullying rates. Teens were surveyed about cyberbullying, and 54% to 64% reported experiencing cyberbullying (95% confidence interval).²³ Answer the following questions based on this interval.

- A newspaper claims that a majority of teens have experienced cyberbullying. Is this claim supported by the confidence interval? Explain your reasoning.
- A researcher conjectured that 70% of teens have experienced cyberbullying. Is this claim supported by the confidence interval? Explain your reasoning.
- Without actually calculating the interval, determine if the claim of the researcher from part (b) would be supported based on a 90% confidence interval?

²³Pew Research Center, A Majority of Teens Have Experienced Some Form of Cyberbullying. September 27, 2018.

5.20 Waiting at an ER, Part II. Exercise 5.11 provides a 95% confidence interval for the mean waiting time at an emergency room (ER) of (128 minutes, 147 minutes). Answer the following questions based on this interval.

- A local newspaper claims that the average waiting time at this ER exceeds 3 hours. Is this claim supported by the confidence interval? Explain your reasoning.
- The Dean of Medicine at this hospital claims the average wait time is 2.2 hours. Is this claim supported by the confidence interval? Explain your reasoning.
- Without actually calculating the interval, determine if the claim of the Dean from part (b) would be supported based on a 99% confidence interval?

5.21 Minimum wage, Part I. Do a majority of US adults believe raising the minimum wage will help the economy, or is there a majority who do not believe this? A Rasmussen Reports survey of 1,000 US adults found that 42% believe it will help the economy.²⁴ Conduct an appropriate hypothesis test to help answer the research question.

5.22 Getting enough sleep. 400 students were randomly sampled from a large university, and 289 said they did not get enough sleep. Conduct a hypothesis test to check whether this represents a statistically significant difference from 50%, and use a significance level of 0.01.

5.23 Working backwards, Part I. You are given the following hypotheses:

$$H_0 : p = 0.3$$

$$H_A : p \neq 0.3$$

We know the sample size is 90. For what sample proportion would the p-value be equal to 0.05? Assume that all conditions necessary for inference are satisfied.

5.24 Working backwards, Part II. You are given the following hypotheses:

$$H_0 : p = 0.9$$

$$H_A : p \neq 0.9$$

We know that the sample size is 1,429. For what sample proportion would the p-value be equal to 0.01? Assume that all conditions necessary for inference are satisfied.

5.25 Testing for Fibromyalgia. A patient named Diana was diagnosed with Fibromyalgia, a long-term syndrome of body pain, and was prescribed anti-depressants. Being the skeptic that she is, Diana didn't initially believe that anti-depressants would help her symptoms. However after a couple months of being on the medication she decides that the anti-depressants are working, because she feels like her symptoms are in fact getting better.

- Write the hypotheses in words for Diana's skeptical position when she started taking the anti-depressants.
- What is a Type 1 Error in this context?
- What is a Type 2 Error in this context?

5.26 Which is higher? In each part below, there is a value of interest and two scenarios (I and II). For each part, report if the value of interest is larger under scenario I, scenario II, or whether the value is equal under the scenarios.

- The standard error of \hat{p} when (I) $n = 125$ or (II) $n = 500$.
- The margin of error of a confidence interval when the confidence level is (I) 90% or (II) 80%.
- The p-value for a Z-statistic of 2.5 calculated based on a (I) sample with $n = 500$ or based on a (II) sample with $n = 1000$.
- The probability of making a Type 2 Error when the alternative hypothesis is true and the significance level is (I) 0.05 or (II) 0.10.

²⁴Rasmussen Reports survey, Most Favor Minimum Wage of \$10.50 Or Higher, April 16, 2019.

Chapter exercises

5.27 Relaxing after work. The General Social Survey asked the question: “After an average work day, about how many hours do you have to relax or pursue activities that you enjoy?” to a random sample of 1,155 Americans.²⁵ A 95% confidence interval for the mean number of hours spent relaxing or pursuing activities they enjoy was (1.38, 1.92).

- Interpret this interval in context of the data.
- Suppose another set of researchers reported a confidence interval with a larger margin of error based on the same sample of 1,155 Americans. How does their confidence level compare to the confidence level of the interval stated above?
- Suppose next year a new survey asking the same question is conducted, and this time the sample size is 2,500. Assuming that the population characteristics, with respect to how much time people spend relaxing after work, have not changed much within a year. How will the margin of error of the 95% confidence interval constructed based on data from the new survey compare to the margin of error of the interval stated above?

5.28 Minimum wage, Part II. In Exercise 5.21, we learned that a Rasmussen Reports survey of 1,000 US adults found that 42% believe raising the minimum wage will help the economy. Construct a 99% confidence interval for the true proportion of US adults who believe this.

5.29 Testing for food safety. A food safety inspector is called upon to investigate a restaurant with a few customer reports of poor sanitation practices. The food safety inspector uses a hypothesis testing framework to evaluate whether regulations are not being met. If he decides the restaurant is in gross violation, its license to serve food will be revoked.

- Write the hypotheses in words.
- What is a Type 1 Error in this context?
- What is a Type 2 Error in this context?
- Which error is more problematic for the restaurant owner? Why?
- Which error is more problematic for the diners? Why?
- As a diner, would you prefer that the food safety inspector requires strong evidence or very strong evidence of health concerns before revoking a restaurant’s license? Explain your reasoning.

5.30 True or false. Determine if the following statements are true or false, and explain your reasoning. If false, state how it could be corrected.

- If a given value (for example, the null hypothesized value of a parameter) is within a 95% confidence interval, it will also be within a 99% confidence interval.
- Decreasing the significance level (α) will increase the probability of making a Type 1 Error.
- Suppose the null hypothesis is $p = 0.5$ and we fail to reject H_0 . Under this scenario, the true population proportion is 0.5.
- With large sample sizes, even small differences between the null value and the observed point estimate, a difference often called the effect size, will be identified as statistically significant.

5.31 Unemployment and relationship problems. A USA Today/Gallup poll asked a group of unemployed and underemployed Americans if they have had major problems in their relationships with their spouse or another close family member as a result of not having a job (if unemployed) or not having a full-time job (if underemployed). 27% of the 1,145 unemployed respondents and 25% of the 675 underemployed respondents said they had major problems in relationships as a result of their employment status.

- What are the hypotheses for evaluating if the proportions of unemployed and underemployed people who had relationship problems were different?
- The p-value for this hypothesis test is approximately 0.35. Explain what this means in context of the hypothesis test and the data.

²⁵National Opinion Research Center, General Social Survey, 2018.

5.32 Nearsighted. It is believed that nearsightedness affects about 8% of all children. In a random sample of 194 children, 21 are nearsighted. Conduct a hypothesis test for the following question: do these data provide evidence that the 8% value is inaccurate?

5.33 Nutrition labels. The nutrition label on a bag of potato chips says that a one ounce (28 gram) serving of potato chips has 130 calories and contains ten grams of fat, with three grams of saturated fat. A random sample of 35 bags yielded a confidence interval for the number of calories per bag of 128.2 to 139.8 calories. Is there evidence that the nutrition label does not provide an accurate measure of calories in the bags of potato chips?

5.34 CLT for proportions. Define the term “sampling distribution” of the sample proportion, and describe how the shape, center, and spread of the sampling distribution change as the sample size increases when $p = 0.1$.

5.35 Practical vs. statistical significance. Determine whether the following statement is true or false, and explain your reasoning: “With large sample sizes, even small differences between the null value and the observed point estimate can be statistically significant.”

5.36 Same observation, different sample size. Suppose you conduct a hypothesis test based on a sample where the sample size is $n = 50$, and arrive at a p-value of 0.08. You then refer back to your notes and discover that you made a careless mistake, the sample size should have been $n = 500$. Will your p-value increase, decrease, or stay the same? Explain.

5.37 Gender pay gap in medicine. A study examined the average pay for men and women entering the workforce as doctors for 21 different positions.²⁶

- (a) If each gender was equally paid, then we would expect about half of those positions to have men paid more than women and women would be paid more than men in the other half of positions. Write appropriate hypotheses to test this scenario.
- (b) Men were, on average, paid more in 19 of those 21 positions. Complete a hypothesis test using your hypotheses from part (a).

²⁶Lo Sasso AT et al. “The \$16,819 Pay Gap For Newly Trained Physicians: The Unexplained Trend Of Men Earning More Than Women”. In: *Health Affairs* 30.2 (2011).