

# 11.1 Significance Tests: The Basics

AP Stats

# I'm a great free-throw shooter!

- I make 80% of my basketball free throws.
- I attempt to validate this claim by shooting 20 free throws.
- Oops! I make only 8 of the 20.
- Does this mean that my claim is false?
- [www.whfreeman.com/tps3e](http://www.whfreeman.com/tps3e)

# What is it?

- A significance test is a formal procedure for comparing observed data with a hypothesis whose truth we want to assess.
- The hypothesis is a statement about a population parameter.
- The results of the test are expressed in terms of a probability that measures how well the data and the hypothesis agree.

# Call the paramedics!

- Vehicle accidents can result in serious injury to drivers and passengers. When they do, someone usually calls 911. Police, firefighters and paramedics respond to these emergency calls as quickly as possible. Slow response times can have serious consequences for accident victims. In case of life-threatening injuries, victims generally need medical attention within 8 minutes of the crash.

# Call the paramedics!

- Several cities have begun to monitor paramedic response times. In one such city, the mean response time to all accidents involving life-threatening injuries last year was  $\mu = 6.7$  minutes with a standard deviation  $\sigma = 2$  minutes. The city manager selects a SRS of 400 calls involving life-threatening injuries and examines the response times. For this sample, the mean response time was  $\bar{x} = 6.48$  minutes. Do these data give good evidence that the response times have decreased?

# Null and Alternative Hypotheses

- The statement being tested in a significance test is called the null hypothesis.
- The significance test is designed to assess the strength of the evidence against the null hypothesis.
- Usually the null hypothesis is a statement of “no effect,” “no difference,” or no change from historical values.
- The claim about the population that we are trying to find evidence for is the alternative hypothesis.

# More...

- We abbreviate the null hypothesis as  $H_0$  and the alternative hypothesis as  $H_a$ .
- Hypotheses always refer to some population, not to a particular outcome.
- Be sure to state your hypotheses in terms of a population parameter.
- One-sided vs. two-sided

# Studying job satisfaction

- Page 692, example 11.3
- The alternative hypothesis should express the hopes or suspicions we have before we see the data.
- It is cheating to first look at the data and then frame the alternative hypothesis to fit what the data show.
- Exercises 11.3 – 11.6

# Conditions for Significance Tests

- SRS
- Normality
  - For means: population distribution Normal or a large sample size.
  - For proportions:  $np \geq 10$  and  $n(1 - p) \geq 10$
- Independence
- From the paramedic response problem, have these conditions been met?

# Test Statistics

- A significance test uses data in the form of a test statistic. Here are some principles that apply to most tests:
  - The test is based on a statistic that compares the value of the parameter as stated in the null hypothesis with an estimate of the parameter from the sample data.
  - Values of the estimate far from the parameter value in the direction specified by the alternative hypothesis give evidence against the null hypothesis.
  - To assess how far the estimate is from the parameter, standardize the estimate.
- In many situations, the test statistic has the form:

$$\text{test statistic} = \frac{\text{estimate} - \text{hypothesized value}}{\text{standard deviation of the estimate}}$$

## Once more...

- Determine the test statistic from the paramedic problem. Remember that the  $\mu = 6.7$  minutes and the  $\sigma = 2$  minutes with an  $\bar{x} = 6.48$  minutes.

# *P*-values

- The probability, computed assuming that the null hypothesis is true, that the observed outcome would take a value as extreme or more extreme than that actually observed is called the *P*-value of the test.
- The **smaller** the *P*-value is, the **stronger** the evidence **against** the null hypothesis provided by the data.
- What is the *P*-value from the paramedic response problem with the  $z = -2.20$ ?

# Calculating a two-sided p-value

- Example 11.7
- [www.whfreeman.com/tps3e](http://www.whfreeman.com/tps3e)
- Exercises 11.7 – 11.12

# Statistical Significance

- We can compare the  $p$ -value with a fixed value that we regard as decisive.
- The decisive value of  $p$  is called the significance level or  $\alpha$ .
- If the  $p$ -value is as small as or smaller than  $\alpha$ , we say that the data are statistically significant at level  $\alpha$ .
- “Significant” in the statistical sense does not mean “important.” It means simply “not likely to happen just by chance.”

# Interpreting Results in Context

- The Three C's
  - Conclusion
  - Connection
  - Context
- There are two accepted methods for drawing conclusions:
  - $p$ -values
  - Statistical Significance and the  $\alpha$  level

# Statistical Significance, revisited

- We can make one of two decisions about the null hypothesis - reject or fail to reject – based on whether our result is statistically significant.
- We will reject the null hypothesis if our sample result is too unlikely to have occurred by chance assuming that the null hypothesis is true.
- In other words, we will reject the null hypothesis if our result is statistically significant at the given  $\alpha$  level and fail to reject if it is not.
- Example 11.9

# WARNING!!

- If you are going to draw a conclusion based on statistical significance, then the significance level should be stated before the data are produced.
- Exercises 11.13 – 11.18

# Section Exercises

- Page 703, 11.19 – 11.26