

## 9.1: Null and Alternative Hypotheses

The actual test begins by considering two **hypotheses**. They are called the **null hypothesis** and the **alternative hypothesis**. These hypotheses contain opposing viewpoints.

$H_0$ : **The null hypothesis**: It is a statement of no difference between the variables—they are not related. This can often be considered the status quo and as a result if you cannot accept the null it requires some action.

$H_a$ : **The alternative hypothesis**: It is a claim about the population that is contradictory to  $H_0$  and what we conclude when we reject  $H_0$ . This is usually what the researcher is trying to prove.

Since the null and alternative hypotheses are contradictory, you must examine evidence to decide if you have enough evidence to reject the null hypothesis or not. The evidence is in the form of sample data.

After you have determined which hypothesis the sample supports, you make a **decision**. There are two options for a decision. They are "reject  $H_0$ " if the sample information favors the alternative hypothesis or "do not reject  $H_0$ " or "decline to reject  $H_0$ " if the sample information is insufficient to reject the null hypothesis.

Table 9.1.1: Mathematical Symbols Used in  $H_0$  and  $H_a$ :

$H_0$	$H_a$
equal ( $=$ )	not equal ( $\neq$ ) <b>or</b> greater than ( $>$ ) <b>or</b> less than ( $<$ )
greater than or equal to ( $\geq$ )	less than ( $<$ )
less than or equal to ( $\leq$ )	more than ( $>$ )

$H_0$  always has a symbol with an equal in it.  $H_a$  never has a symbol with an equal in it. The choice of symbol depends on the wording of the hypothesis test. However, be aware that many researchers (including one of the co-authors in research work) use  $=$  in the null hypothesis, even with  $>$  or  $<$  as the symbol in the alternative hypothesis. This practice is acceptable because we only make the decision to reject or not reject the null hypothesis.

### ✓ Example 9.1.1

- $H_0$ : No more than 30% of the registered voters in Santa Clara County voted in the primary election.  $p \leq 30$
- $H_a$ : More than 30% of the registered voters in Santa Clara County voted in the primary election.  $p > 30$

### ? Exercise 9.1.1

A medical trial is conducted to test whether or not a new medicine reduces cholesterol by 25%. State the null and alternative hypotheses.

**Answer**

- $H_0$ : The drug reduces cholesterol by 25%.  $p = 0.25$
- $H_a$ : The drug does not reduce cholesterol by 25%.  $p \neq 0.25$

### ✓ Example 9.1.2

We want to test whether the mean GPA of students in American colleges is different from 2.0 (out of 4.0). The null and alternative hypotheses are:

- $H_0 : \mu = 2.0$
- $H_a : \mu \neq 2.0$

### ? Exercise 9.1.2

We want to test whether the mean height of eighth graders is 66 inches. State the null and alternative hypotheses. Fill in the correct symbol ( $=$ ,  $\neq$ ,  $\geq$ ,  $<$ ,  $\leq$ ,  $>$ ) for the null and alternative hypotheses.

- $H_0 : \mu\_66$
- $H_a : \mu\_66$

#### Answer

- $H_0 : \mu = 66$
- $H_a : \mu \neq 66$

### ✓ Example 9.1.3

We want to test if college students take less than five years to graduate from college, on the average. The null and alternative hypotheses are:

- $H_0 : \mu \geq 5$
- $H_a : \mu < 5$

### ? Exercise 9.1.3

We want to test if it takes fewer than 45 minutes to teach a lesson plan. State the null and alternative hypotheses. Fill in the correct symbol ( $=$ ,  $\neq$ ,  $\geq$ ,  $<$ ,  $\leq$ ,  $>$ ) for the null and alternative hypotheses.

- a.  $H_0 : \mu\_45$
- b.  $H_a : \mu\_45$

#### Answer

- a.  $H_0 : \mu \geq 45$
- b.  $H_a : \mu < 45$

### ✓ Example 9.1.4

In an issue of *U. S. News and World Report*, an article on school standards stated that about half of all students in France, Germany, and Israel take advanced placement exams and a third pass. The same article stated that 6.6% of U.S. students take advanced placement exams and 4.4% pass. Test if the percentage of U.S. students who take advanced placement exams is more than 6.6%. State the null and alternative hypotheses.

- $H_0 : p \leq 0.066$
- $H_a : p > 0.066$

### ? Exercise 9.1.4

On a state driver's test, about 40% pass the test on the first try. We want to test if more than 40% pass on the first try. Fill in the correct symbol ( $=$ ,  $\neq$ ,  $\geq$ ,  $<$ ,  $\leq$ ,  $>$ ) for the null and alternative hypotheses.

- a.  $H_0 : p\_0.40$
- b.  $H_a : p\_0.40$

#### Answer

- a.  $H_0 : p = 0.40$
- b.  $H_a : p > 0.40$

## COLLABORATIVE EXERCISE

Bring to class a newspaper, some news magazines, and some Internet articles . In groups, find articles from which your group can write null and alternative hypotheses. Discuss your hypotheses with the rest of the class.

## Review

In a **hypothesis test**, sample data is evaluated in order to arrive at a decision about some type of claim. If certain conditions about the sample are satisfied, then the claim can be evaluated for a population. In a hypothesis test, we:

1. Evaluate the **null hypothesis**, typically denoted with  $H_0$ . The null is not rejected unless the hypothesis test shows otherwise. The null statement must always contain some form of equality ( $=$ ,  $\leq$  or  $\geq$ )
2. Always write the **alternative hypothesis**, typically denoted with  $H_a$  or  $H_1$ , using less than, greater than, or not equals symbols, i.e., ( $\neq$ ,  $>$ , or  $<$ ).
3. If we reject the null hypothesis, then we can assume there is enough evidence to support the alternative hypothesis.
4. Never state that a claim is proven true or false. Keep in mind the underlying fact that hypothesis testing is based on probability laws; therefore, we can talk only in terms of non-absolute certainties.

## Formula Review

$H_0$  and  $H_a$  are contradictory.

If $H_a$ has:	equal ( $=$ )	greater than or equal to ( $\geq$ )	less than or equal to ( $\leq$ )
then $H_0$ has:	not equal ( $\neq$ ) or greater than ( $>$ ) or less than ( $<$ )	less than ( $<$ )	greater than ( $>$ )

- If  $\alpha \leq p\text{-value}$ , then do not reject  $H_0$ .
- If  $\alpha > p\text{-value}$ , then reject  $H_0$ .

$\alpha$  is preconceived. Its value is set before the hypothesis test starts. The  $p$ -value is calculated from the data.

References  
Data from the National Institute of Mental Health. Available online at <http://www.nimh.nih.gov/publicat/depression.cfm>.

## Glossary

### Hypothesis

a statement about the value of a population parameter, in case of two hypotheses, the statement assumed to be true is called the null hypothesis (notation  $H_0$ ) and the contradictory statement is called the alternative hypothesis (notation  $H_a$ ).

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