6.1: Developing Hypotheses

Inferential statistics are used to test hypotheses. This is generally done by testing data from samples to learn what is likely true of populations. Hypothesis testing is central to behavioral sciences such as psychology. Before we can learn *how* to use inferential statistics to test hypotheses, we must first become familiar with two main things:

1. The types of, and details surrounding, hypotheses, and
2. The foundational concepts that connect and differentiate samples from populations.

Reviewing these two areas will provide the necessary foundation before we can embark on hypothesis testing.

Developing Hypotheses

Hypothesis testing is central to our work as researchers and statisticians. Two important skills to develop are the ability to generate testable hypotheses and the ability to correctly choose and use strategies to test those hypotheses. Researchers follow the scientific method by starting with making observations and reviewing existing knowledge. Therefore, researchers often have a general topic or question in mind and will then read existing, relevant research and theories to refine their question. When they have narrowed in, they will have a research question. As is overtly stated in the name, a **research question** is a question that a researcher or statistician intends to answer by analyzing data. When research is more exploratory in nature, the researcher may move forward solely with the research question to guide their work. However, scientific fields are aided by moving from research questions to hypotheses before planning for and collecting data. **Research hypotheses** are testable, expected answers to research questions that draw on larger theories, previous findings, and/or strong arguments. These forms of hypotheses can also be referred to as *alternative hypotheses* or simply as *hypotheses.* Designing studies, collecting data, and analyzing data depend upon the hypotheses that foment the research. Thus, inferential statistics and all the components that go along with it follow the formation and clear statement of a research hypothesis.

Stating a Research Hypothesis

Research hypotheses should be clear and specific, yet also succinct. A hypothesis should also be testable. If we state a hypothesis that is impossible to test, it forecloses any further investigation. To the contrary, a hypothesis should be what directs and demands investigation. In addition, a hypothesis should be directional, when possible. A **directional hypothesis** is one that includes information about the mathematical movement or difference that is expected; the direction tells which way you think the pattern(s) in the data will go. For example, if a researcher hypothesizes that teenagers and adults have *different* mean hours of sleep, their hypothesis is non-directional. This is because the hypothesis states a difference is anticipated

without specifying which group will have more or less sleep than the other. It could be that teenagers sleep more and adults sleep less or that teenagers sleep less and adults sleep more. In this example there are two opposing outcomes that could support the hypothesis. However, it is preferable to narrow the hypothesis down so that only one, specific outcome would support the hypothesis. If a researcher hypothesized that teenagers would sleep *more* hours than adults, their hypothesis would be directional. There is only one pattern in the data that could support this hypothesis: that the teens had comparatively *more* hours of sleep and adults had comparatively less sleep. Hypotheses such as these should be used whenever there is good reason to narrow in to one direction.

Whenever a hypothesis is stated, a hypothesis that counters it is also simultaneously being proposed which is known as a null hypothesis. A **null hypothesis** is a statement about a population that counters a research hypothesis and which is presumed to be true until there is sufficient evidence to refute or reject it. Because the null hypothesis is presumed to be true until there is sufficient evidence to support the research hypothesis and simultaneously reject the null hypothesis, research hypotheses are often called *alternative* hypotheses to reiterate that they are proposed alternatives to what is otherwise presumed to be true (which is the null hypothesis).

The assumption that the null hypothesis is true may seem counterintuitive at first as hypotheses are often grounded in theories and/or prior research, but there is an important reason for this: it requires that a researcher tests their presumptions (which are stated as their hypotheses) before they can present those presumptions as possible truths. This is what moves a field from being purely philosophical to empirical and, ultimately, scientific. Recall that a hypothesis should be testable. When a hypothesis is testable it means it is also falsifiable. **Falsifiable** means that something can be disproven or shown to be false if indeed it is not true. The onus is on the researcher to develop testable (and, thus, falsifiable) hypotheses and to test them before putting those hypotheses forth as possible facts. This process serves as an important filter between untested ideas (which can be stated as hypotheses) and supported contentions (hypotheses which have been supported by evidence).

Symbols

Abbreviations and symbols are often used to state the null and alternative (i.e. research) hypotheses. Population symbols are used for the null hypothesis. An important property of alternative hypotheses is that they describe predicted values of population parameters (not sample statistics). The alternative hypothesis, therefore, can be written with the population symbols to indicate that the researcher expects the hypothesis to be true beyond the sample. However, the alternative hypothesis can also be written with sample symbols to reiterate that the data used to test it are from samples and can only be used to estimate the population. This is because one of the principles of hypothesis testing is that we determine the sample statistics in order to infer the population parameters. Thus, sample symbols are sometimes used for alternative hypotheses to emphasize the distinction between what is estimated through the use of sample data from what is true about populations.

The name "alternative hypothesis" can be abbreviated with the symbols H_a where the H stands for the word "hypothesis" and the subscript *a* abbreviates the word "alternative." However, it is common for researchers to test more than one hypothesis in a single study. When doing so, it would be confusing to list several hypotheses with the same symbols. Therefore, it is also appropriate to enumerate the hypotheses in the order in which they will be tested using consecutive numbers in place of *a* in the subscript. Thus, H_1 would be used as the abbreviation for the first hypothesis, H_2 for the second hypothesis, H_3 for the third hypothesis, and so on until each alternative hypothesis has been specified.

The null hypothesis is abbreviated with the symbols H_0 because zero is synonymous with the word null. When a researcher states an alternative hypothesis, the null hypothesis is presumed and typically does not need to be overtly stated. Thus, null hypotheses are often all referred to simply as H_0 without additional enumeration when they are written because they will be presented alongside their corresponding alternative hypothesis, if presented at all.

However, sometimes a researcher will overtly state both the alternative hypothesis and its corresponding null hypothesis (especially when they are taking a class and first learning how alternative and null hypotheses work). The researcher also makes the decision about whether the alternative hypothesis will be directional or non-directional based on information obtained from a review of prior research and theories. The alternative and null hypotheses for a given research question are mutually exclusive. Mutually exclusive means that if one of these two forms of hypothesis is true, the other one must be false. For example, only one of the following hypotheses in each pair can be true:

Pair 1

- **Directional, alternative hypothesis:** Last-minute studying will increase students' understanding of inferential statistics.
- **Null hypothesis:** Last-minute studying will not increase students' understanding of inferential statistics.

Pair 2

- **Non-directional, alternative hypothesis:** Last-minute studying will have an effect on students' understanding of inferential statistics.
- **Null hypothesis:** Last-minute studying will have no effect on students' understanding of inferential statistics.

Data can only support one statement in each pair and refute the other because each pair of hypotheses (alternative and null) are mutually exclusive.
