Topic: Testing Statistical Hypotheses

Learning goals: By the end of this class session, you will be able to:

1. Specify statistical hypotheses to test, given a word problem.
2. Describe the process of hypothesis testing.

PART 1: Specifying statistical hypotheses

Background and vocabulary

- **Goal:** Use the process of statistical testing to determine if a hypothesis provides a plausible explanation for the data that we collected.
- As a first step in that process, *we must specify the hypotheses* that we are testing.

- **Hypotheses:** statements about a parameter (a numerical characteristic of the population).

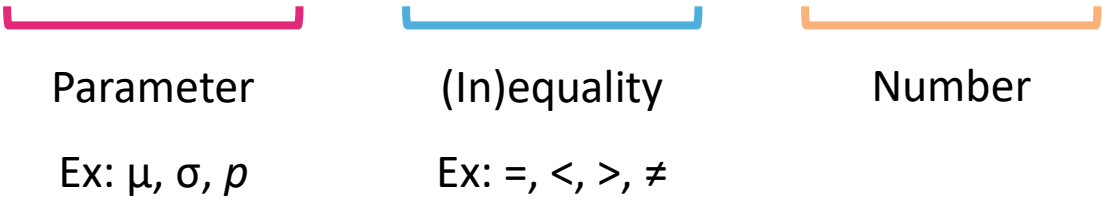
    - **Null hypothesis:** A statement about the population parameter that specifies the "status quo".

        - No difference in the population.

    - **Alternative hypothesis:** A statement about the population parameter that specifies the research hypothesis of interest.

        - Opposite – no difference in the population.

- Writing hypotheses with symbols:



Example

- **Background:** It is known that 10% of the population is left-handed. A professor at Z University speculates that students at Z are more likely to left-handed than people found in the general population. The professor asks a sample of students at Z University if they are left-handed or right-handed and records the results.

- **Research question:** Are students at Z University more likely to be left-handed than people from the general population?

- **Parameter of interest:** p, the true proportion of all Z University students who are left-handed

- Fill in the hypotheses in the table below.

	Words	Symbols
Null hypothesis	Z University students are just as likely to be left-handed as people in the general population.	$p = .10$
Alternative hypothesis	Z University students are more likely to be left-handed than people in the general population.	$p > .10$

PART 2: The process of hypothesis testing
Case Study

- **Background:** Acute myocardial infarction (MI, or heart attack) is a common cause of hospitalization, and its early and accurate diagnosis is critical for successful treatment and improved patient outcomes. To investigate MI misdiagnosis rates, Wu et al. (2018) conducted a national cohort study including all National Health Service (NHS) hospitals in England and Wales that provide care for adult patients. Of the 564,412 patients discharged with a final diagnosis of myocardial infarction, 168,534 (29.9%) patients had an initial diagnosis that was not the same as their final diagnosis.
    - https://www.bmj.com/content/bmj/354/bmj.i4713.full.pdf
- **Our study:** Imagine you are the director of a large hospital in Wales. You want to show that your hospital has a better MI misdiagnosis rate than that found in Wu et al. (2018). To investigate this, you select a random sample of 50 patients who were discharged with an MI diagnosis in 2021 and investigate their medical records. For each selected patient, you record whether their initial diagnosis was MI, or something else.

Case Study: Setting the hypotheses
Answer the following questions in your groups:

1. *What is the research question in this study?*

   Does my hospital have a better MI misdiagnosis rate than that found in Wu et al. (2018)?

2. *What is the parameter of interest in this study?*

   p, the true proportion of MI patients who were misdiagnosed in my hospital.

3. *Write down the hypotheses being investigated in this study in both words and symbols.*

	Words	Symbols
Null hypothesis	My hospital has the same MI misdiagnosis rate as Wu et al. (2018).	$p = .299$
Alternative hypothesis	My hospital has a better MI misdiagnosis rate than that found in Wu et al. (2018).	$p < .299$

Case Study: Collecting data and calculating a statistic

- **Our strategy:** You select a random sample of 50 patients who were discharged with an MI diagnosis in 2021 and investigate their medical records. For each selected patient, you record whether their initial diagnosis was MI, or something else.

- **Results:** Of the 50 records in your sample, 38 had an initial diagnosis of MI and 12 had an initial diagnosis that *was not* MI.

    - **Sample statistic:** p_hat = proportion of sample that had initial diagnosis that *was not* MI = 12 / 50 = .24

Answer the following question individually:

4. *Based on the evidence you have so far, do you think the initial MI misdiagnosis rate at your hospital is lower than that of Wu et al. (2018)? How certain are you about your answer?*

   Potential answers: .24 < .299, so there is evidence that our hospital does have a lower MI misdiagnosis rate, varying degrees of certainty…

Case Study: Compare your sample results to the null distribution

- Imagine that that the initial MI misdiagnosis rate at our hospital *is actually the same* as that of Wu et al. (2018).
    - Our initial MI misdiagnosis rate is 29.9%.

- If this is the case, what could our sample results look like?
    - Use a web application to generate samples of 50 medical records from a hospital where the true initial MI misdiagnosis rate is 29.9%.
    - For each sample you will see the number that were initially misdiagnosed and the number that were initially correctly diagnosed.

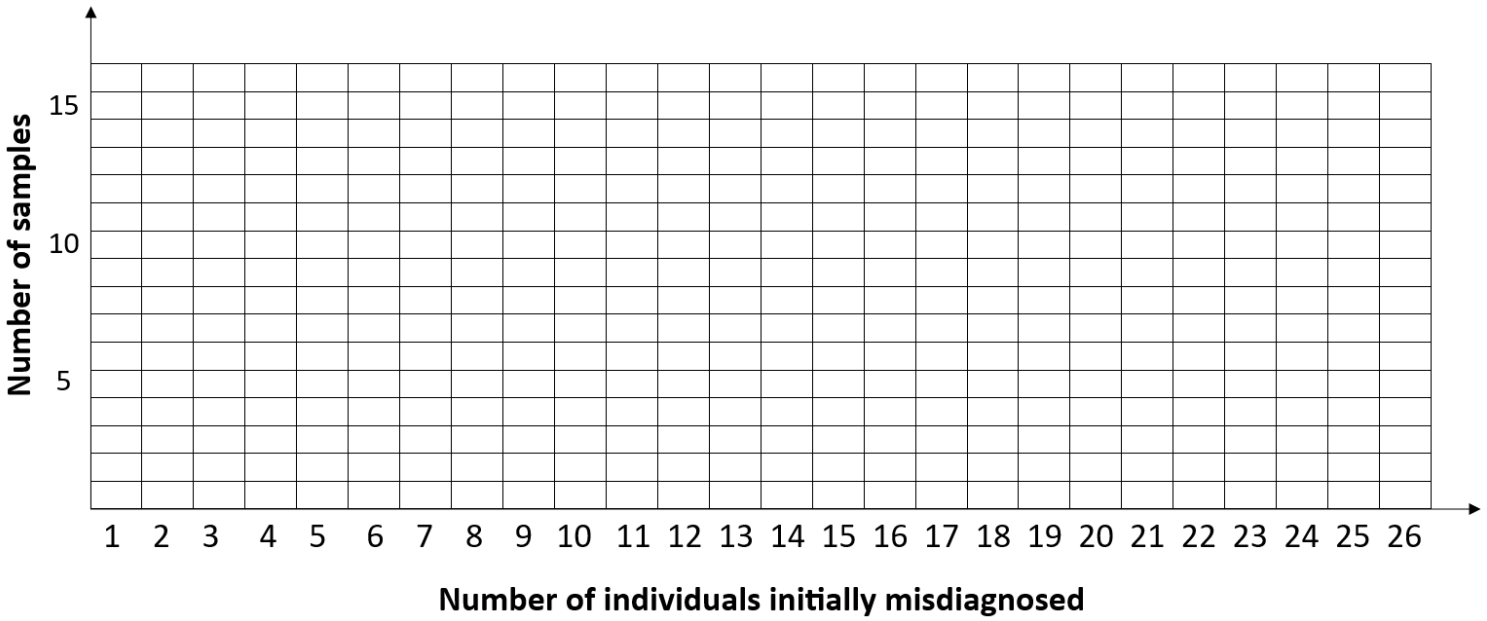
Group work

- In your groups, generate samples using the app and record your results in the provided graph (on the next page).
    - Fill in a box above the number you record for each sample.
    - Draw enough samples to arrive at a conclusion (at least ~20).

- Each group member should have a unique role:
    - **Sampler:** This individual generates the samples using the web application.
    - **Recorder:** This individual records the sample result on the histogram.
    - **Tracker:** This individual keeps track of how many samples were drawn.

- Record the name of the group member in each role:
    - **Sampler:**
    - **Recorder:**
    - **Tracker:**

- URL for the app: https://bit.ly/MI_app



Case Study: Decide if the null hypothesis is plausible
Answer these questions as a group, after you fill in the graph:

5. *Look at the graph that your group made using the null samples. Compare this to the results you obtained from your own hospital sample. As a group, what do you think this suggests about the hypotheses in this study? Do you think the initial MI misdiagnosis rate at your hospital is lower than that of Wu et al. (2018)?*

   Potential answers: We got 12 misdiagnoses in our sample. This was also likely from the null sample. This suggests that the claim that the misclassification rate at our hospital is the same as Wu et al. (2018) is plausible. I don't think our MI misdiagnosis rate is lower than 29.9% for sure.

6. *If you have time, also discuss your individual answers to question #4. Did you change your mind after generating null samples?*

   Potential answers: Perhaps don't feel as certain as before, perhaps minds changed, etc.

Reviewing the hypothesis testing process

1. Identify the research question.
2. Identify a quantity related to the research question that we do not know. This quantity is called a **parameter**.
3. Write the **statistical hypotheses** in terms of the parameter of interest.
4. Collect data and calculate a statistic.
5. Compare your calculated statistic to the null distribution.
6. Decide if the null hypothesis is a plausible explanation for the data, compared to the alternative hypothesis.