Testing Statistical Hypotheses

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Sample Course

Date

Using Statistics to Call Out Nonsense

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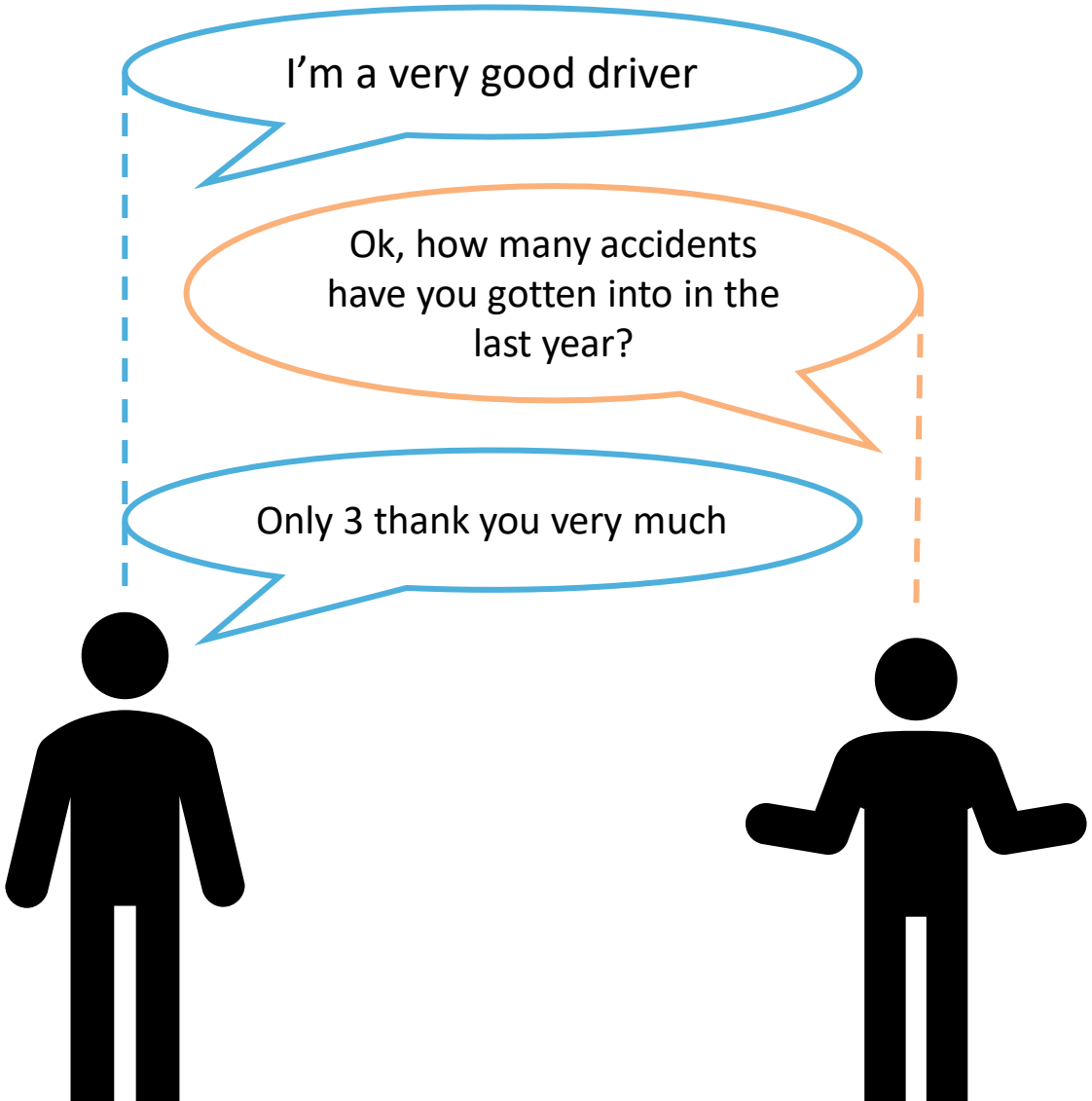

- If your friend was *actually* a good driver, do you think it is likely that they would have three car accidents in a year?

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.

1. Specifying statistical hypotheses

Specifying statistical hypotheses

- **Goal:** Use the process 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.

Definitions

- **Hypotheses** are 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 – there is a difference in the population.

- Writing hypotheses with symbols:

Parameter
Ex: μ, σ, *p*

(In)equality
Ex: =, <, >, ≠

Number

Setting the hypotheses: 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 Z University students 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.

Setting the hypotheses: 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.

	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.	$p > .10$

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.

Study: https://www.bmj.com/content/bmj/354/bmj.i4713.full.pdf

Case Study: 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 questions in your groups:

1. What is the research question in this study?

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

3. Fill in the hypotheses in the provided table.

Case Study: Setting the hypotheses

Answer the questions provided in your groups:

1. **Research question:** Does our hospital have a better MI misdiagnosis rate than that found in Wu et al. (2018)?
2. **Parameter of interest:** *p,* the proportion of initially misdiagnosed MI patients at our hospital.
3. **Hypotheses:**

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

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: 12 / 50 → 24%

Collecting data and calculating a statistic

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Based on these results, 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?

Compare your sample results to the null distribution

- Imagine 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%

Compare your sample results to the null distribution

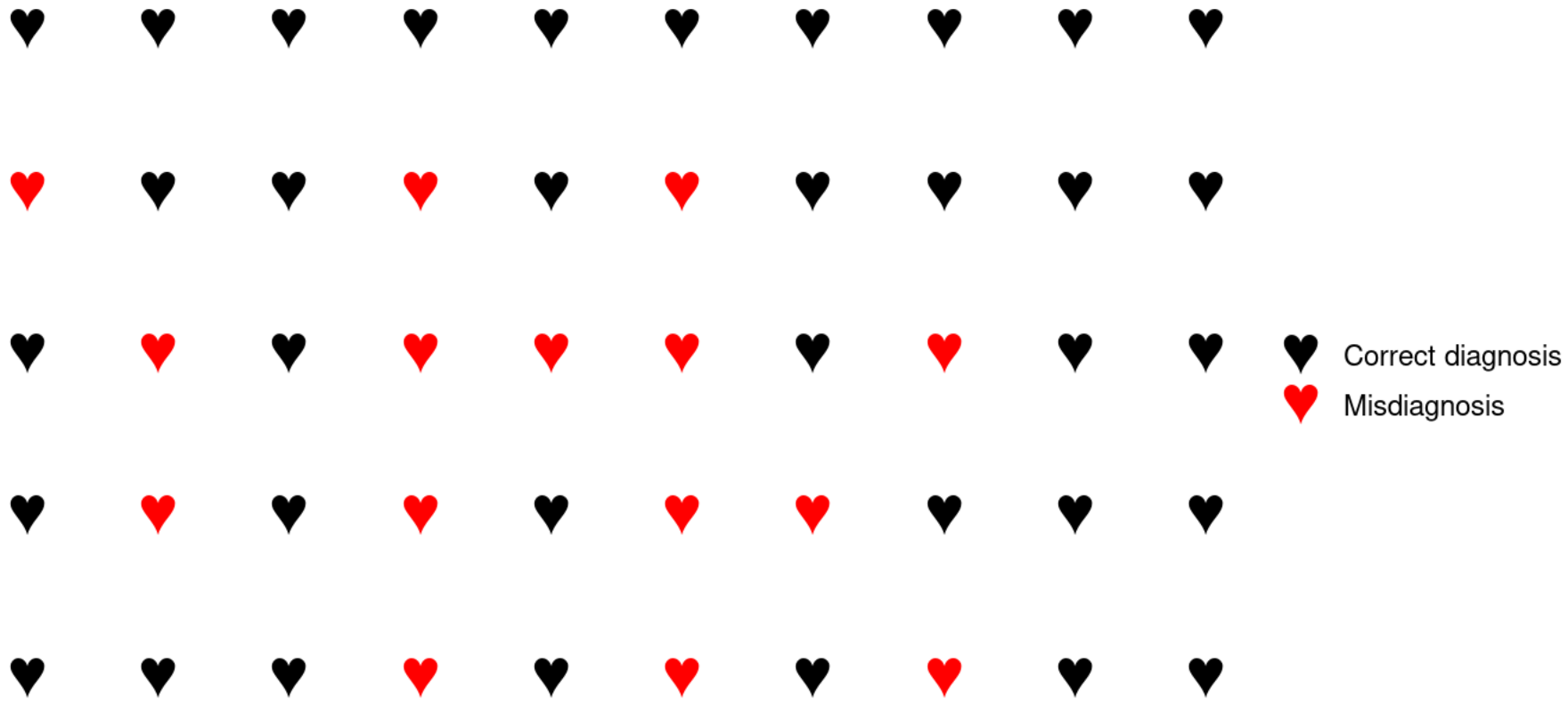
- Imagine that the initial MI misdiagnosis rate at our hospital *is actually the same* as that of Wu et al. (2018).
  - Our initial MI misdiagnosis rate is 29.9%

- 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 originally correctly diagnosed.

Null sample generator

Click the button below to generate a sample under the null distribution. The plot to the right will display the 50 discharged MI patients in the sample. Patients are represented by heart icons. Hearts that are colored black indicate that the individual had a correct initial diagnosis. Hearts colored in red indicate that the individual was initially misdiagnosed. This sample is generated assuming that the percentage of patients who are initially misdiagnosed is 29.9%.

Generate a null sample

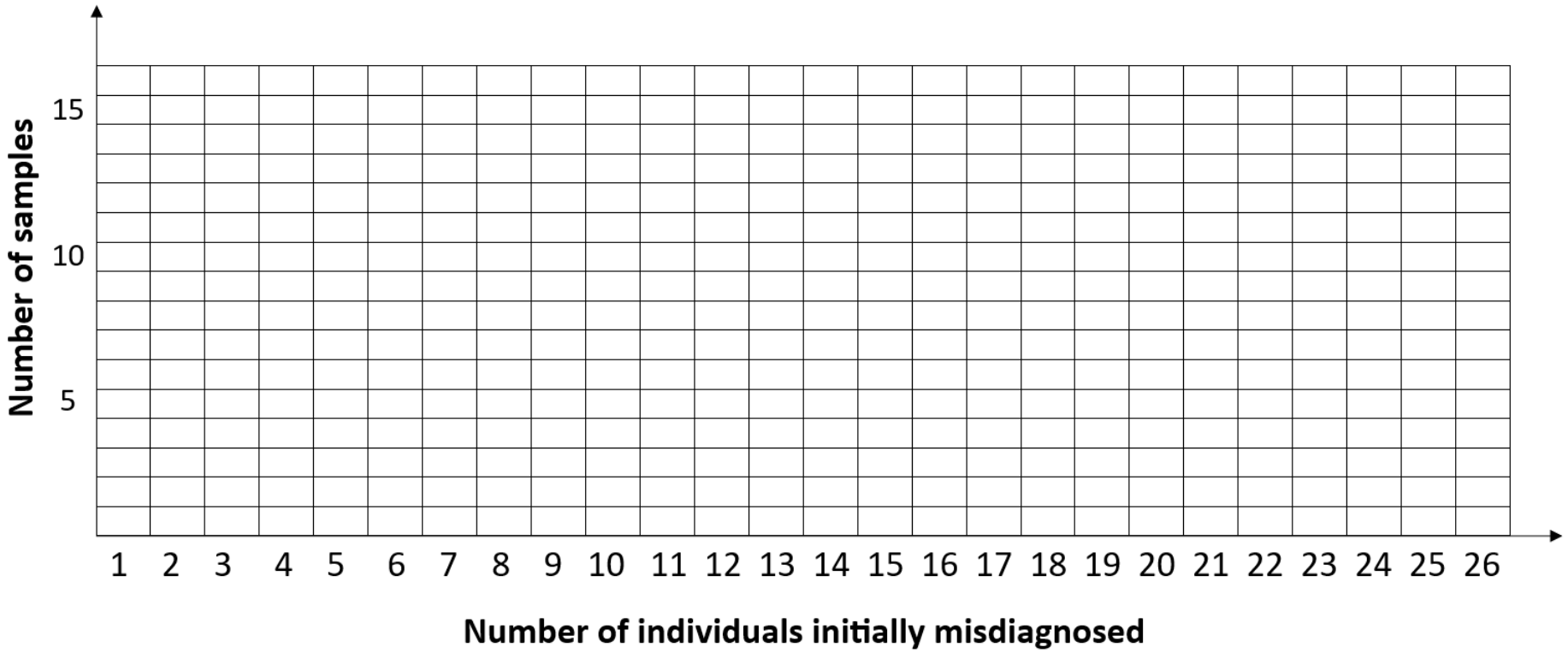


The number of people who were initially misdiagnosed: 15

Compare your sample results to the null distribution

In your groups, generate samples using the app and record your results in the provided graph.

- Fill in a box above the number you record for each sample.
- Draw enough samples to arrive at a conclusion (at least ~20).



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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.

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

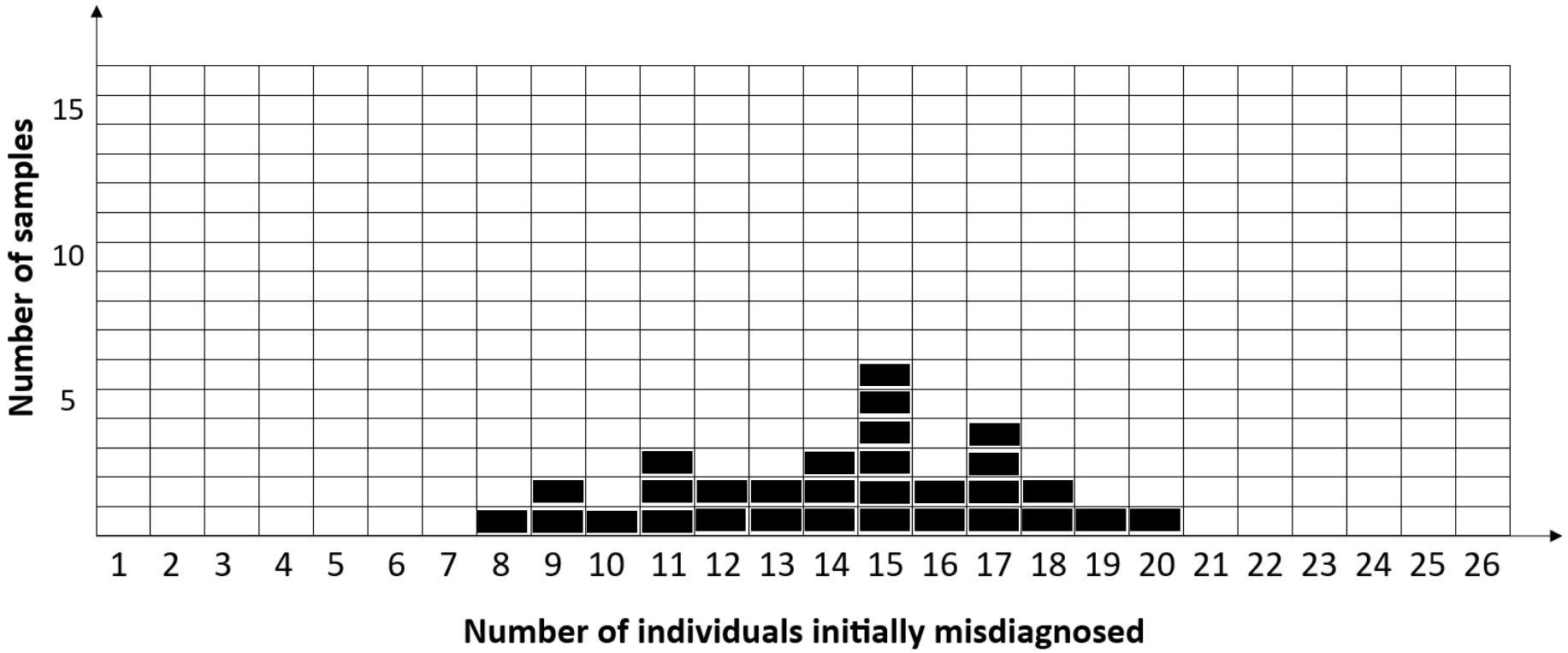
Decide if the null hypothesis is plausible

Group questions:

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)?

6. Discuss your individual answers to question #4. Did you change your mind after generating null samples?

Decide if the null hypothesis is plausible



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.