# Lec 6: Testing Hypothesis 1

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# Hypothesis testing

## The research question:

In any research project, it is not enough for the researcher to have an idea, we need to formulate it into a research question.

**A research question should be:**

- A question
- Specific (time/place/subjects/condition)
- Answerable
- Novel
- Relevant to medical knowledge

**Examples of research questions:**

- What is the prevalence of diabetes mellitus in Egypt?
- Does lowering blood pressure reduce the risk of coronary heart disease in diabetic patients?
- Is prognosis following stroke dependent on age at the time of the event?
- Is drug A better than drug B in lowering blood pressure?
- Is there a difference between males and females regarding response to drug X?

If we have a research question and we want to reach a conclusion about it, we do what is called hypothesis testing.

## Steps for hypothesis testing

1. Define the null and alternative hypotheses.
2. Choose the level of significance.
3. Pick and compute the test statistic.
4. Compute the p-value
5. Check whether to reject the null hypothesis by comparing the p-value to the level of significance.
6. Draw conclusion from the test.

We will go through those steps in detail.

## The null and alternative hypotheses

Before starting with any statistical analysis, we begin with defining the "hypotheses" based on the research question we are trying to answer.

For each research question, we define two types of hypotheses; the **null hypothesis ($H_o$)** and the **alternative hypothesis ($H_1$)**.

Both are mutually exclusive (not overlapping). Only one of them is true!

| $H_o$: Null hypothesis | $H_1$ /$H_a$: Alternative hypothesis |
|---|---|
| ▪ Is the currently accepted belief/ idea /parameter<br>▪ Nothing is happening / there is no difference / there is no association<br>▪ The researcher doubts it to be true | ▪ Is the researcher's idea<br>▪ something is happening/ there is a difference/ there is an association<br>▪ The researcher believesit to be true and wishes to prove |

**Examples:**

**1)**

| **Research question** | **Is there a difference in the exam scores between males and females?** |
|---|---|
| **The null hypothesis ($H_o$)** | The difference between two groups' means is zero<br>Mean score of the males = mean score of the females<br>Mean score of the males – mean score of the females= 0 |
| **The alternative hypothesis ($H_1$)** | The difference between the two groups' means is not zero<br>Mean score of the males ≠ mean score of the females<br>Mean score of the males – mean score of the females≠ 0 |

2)

| Research question | Does a new diabetes treatment reduce blood glucose different than an existing treatment? |
|---|---|
| **The null hypothesis ($H_o$)** | The mean reduction in blood glucose level is the same in the two treatment groups. |
| **The alternative hypothesis ($H_1$)** | the mean reduction in blood glucose is different in the two treatment groups. |

**3)**

| **Research question** | **Is there an association between smoking and the risk of cardiovascular diseases?** |
|---|---|
| **The null hypothesis ($H_o$)** | There is no association between smoking and the risk of cardiovascular disease. |
| **The alternative hypothesis ($H_1$)** | There is an association between smoking and the risk of cardiovascular disease. |

We perform a statistical analysis to test our hypotheses and reach a conclusion regarding the null and alternative hypotheses.

**The conclusion is either :**

- Fail to reject the null hypothesis (accept the null hypothesis) and conclude that nothing is happening / no difference / no association.
- Reject the null hypothesis (accept the alternative hypothesis) and conclude that something is happening/ there is a difference / there is an association.

**The decision is done regarding the null hypothesis**

We use REJECTING & FAILING TO REJECT (not accepting)
• Acceptance implies that the null hypothesis is true.
• Failure to reject implies that the data are not sufficiently persuasive for us to prefer the alternative hypothesis over the null hypothesis

## One-tailed and two-tailed tests:

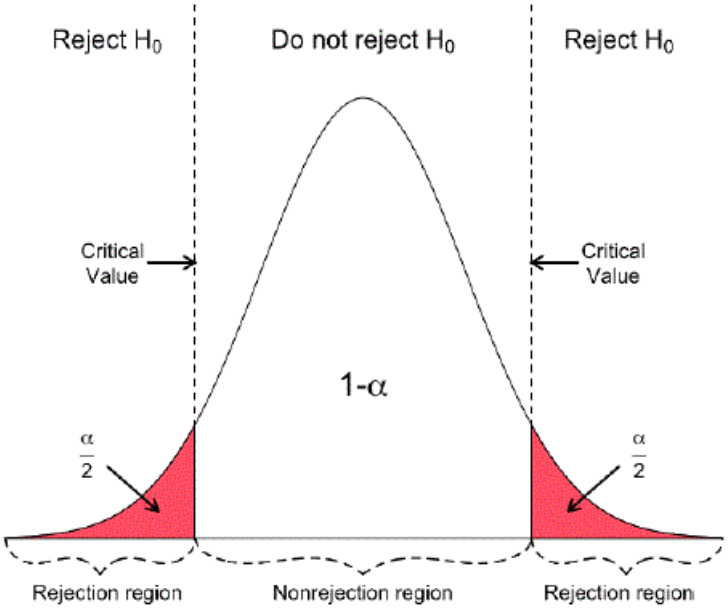
Based on the alternative hypothesis, the used statistical test can be either a two-tailed test or a one-tailed test

| The two-tailed tests | The one-tailed tests |
|---|---|
| ▪ The alternative hypothesis allows for the difference **to be in either of the two directions**.<br>▪ As in previous examples:<br>Exam scores could be higher for males or females, and any of the two drugs may reduce blood glucose more than the other.<br>**$H_o$ : drug A = drug B**<br>**$H_1$ : drug A ≠ drug B** | ▪ The alternative hypothesis is **in one direction only.**<br>For example:<br>▪ We have a new drug A, and we want to examine only if it is **better** than standard drug B.<br>**$H_o$ : drug A ≤ drug B**<br>**$H_1$ : drug A > drug B** |

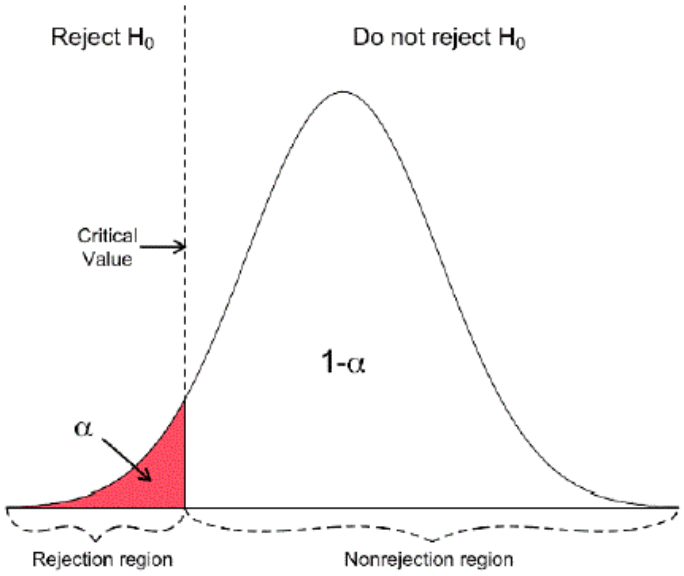
In most cases, we use the two-tailed tests unless there is a clear justification for using a one-tailed test.

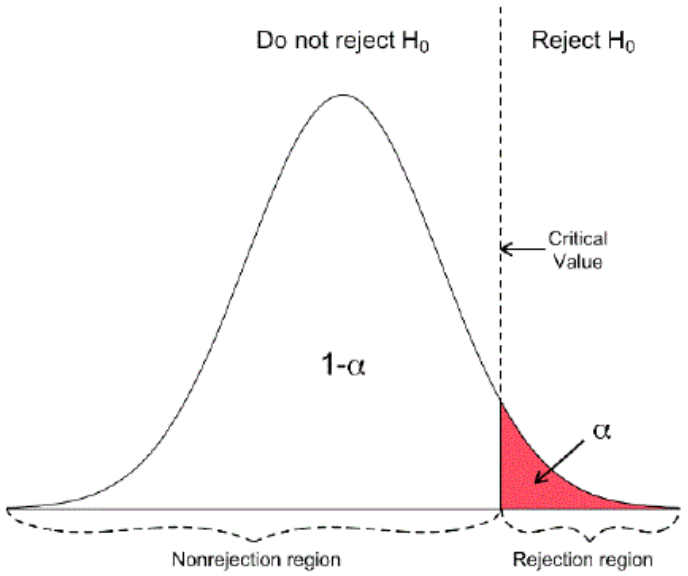
The following graphs illustrate the difference between the two types :

**Two-tailed tests:**



## One tailed tests:



## Type 1 and type 2 errors

There are two types of errors that can be committed while performing statistical analysis (hypothesis testing), type 1 errors and type 2 errors.

They are illustrated using the following 2 cases:

**Case 1:**

**In the real world (population): Smoking rate in males = smoking rate in females**

We have a research idea (question) that smoking rates are different in the two groups

As before,

$H_0$: Null hypothesis: nothing is happening / no difference

$H_1$: Alternative hypothesis: the idea of the researcher

So,

**$H_0$:** Smoking rate in males = smoking rate in females

**$H_1$:** Smoking rate in males ≠ smoking rate in females

**Decisions based on the statistical test:**

1- Accept the null hypothesis and conclude that smoking rate in males = smoking rate in females.

(which is the correct decision)

2- Reject the null hypothesis, accept the alternative hypothesis and conclude that smoking rate in males ≠ smoking rate in females.

(here we made a mistake)

**Type I error / false positive / α**

**Here, we made a mistake by rejecting a true null hypothesis and is called type I error, or α. We reached a false positive conclusion.**

This type of error is serious, as we reach a false positive conclusion (we accept the alternative hypothesis of the researcher). This (false) conclusion may be that a drug is effective while it is not, or something is a risk factor for a disease while it is not!

Researchers tend to keep the probability of this type of error as low as possible.

It is usually set at 5% ($\alpha$=0.05) and sometimes they are even more conservative and make it 1% ($\alpha$=0.01).

**Case 2:**

**In the real world (population): Smoking rate in males ≠ smoking rate in females**

We have a research idea (question) that smoking rates are different in the two groups

As before,

**$H_0$:** Null hypothesis: nothing is happening / no difference

**$H_1$:** Alternative hypothesis: the idea of the researcher

So, **$H_0$:** Smoking rate in males = smoking rate in females

**$H_1$:** Smoking rate in males ≠ smoking rate in females

**Decisions based on the statistical test:**

1- Reject the null hypothesis, accept the alternative hypothesis and conclude that smoking rate in males ≠ smoking rate in females

(which is the correct decision)

2- Accept the null hypothesis and conclude that smoking rate in males = smoking rate in females

(here we made a mistake)

**Type II error / false negative / β**

**Here, we made a mistake by accepting a false null hypothesis and is called type II error, or β. We reached a false negative conclusion.**

This type of error is less serious than the first one as we here reach a false negative conclusion which means that we conclude that a drug is not effective while it is truly effective.

The probability of this type of error is usually set at 20% ($\beta$=0.2).

The following graph illustrates type 1 and type 2 errors.

| | | **The Truth** (Based on the entire population) | |
|---|---|---|---|
| | | Nothing is there **$H_0$ is True** | Something is there **$H_0$ is False** |
| Your conclusion (Based on your sample) | I do not see anything (Non-significant) | ✓ | ✗ **Type II error** |
| | I see something (Significant) | ✗ **Type I error** | ✓ |

**The probabilities of the two errors are inversely related.**