

# Estimation and Hypothesis Testing

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# Agenda

1. Sampling & Central Limit Theorem
2. Estimation
3. Null and Alternative hypothesis
4. Hypothesis testing steps
5. Hypothesis formulation
6. One-tailed and two-tailed tests
7. Type I and Type II errors

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# Pop Quiz

1. Why do we need sampling?
2. What makes the central limit theorem so important?
3. What do you mean by interval estimation ?
4. What is null and alternative hypothesis?
5. What are the steps to perform a hypothesis test?
6. What is the way to formulate a correct hypothesis?
7. What is the difference between one-tailed and two-tailed tests?
8. What are type I and type II errors?

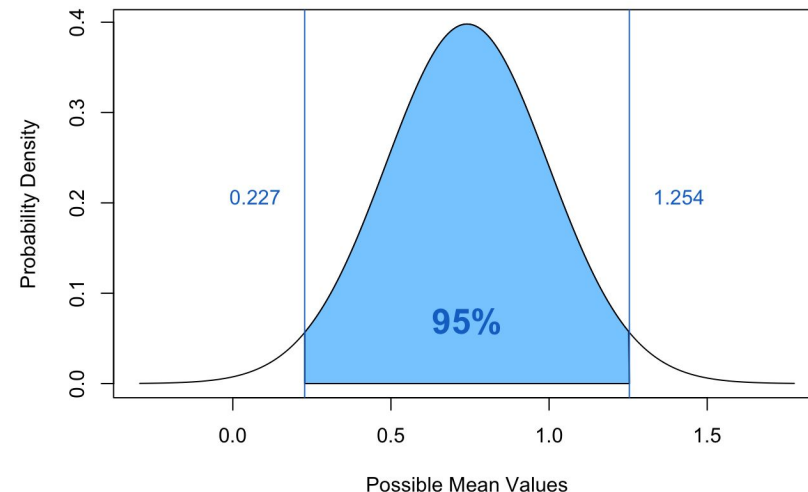
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# Sampling Distributions

- **Need for sampling**
  - Given the limited resources and time, it is not always possible to study the population. That's why we choose a sample out of the population to make inference about the population
- **Sampling Distributions**
  - It is a distribution of a particular sample statistic obtained from all possible samples drawn from a specific population



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# Central Limit Theorem

The sampling distribution of the sample means will approach normal distribution as the sample size gets bigger, no matter what the shape of the population distribution is.

## Assumptions

Data must be **randomly sampled**

Sample values must be **independent** of each other

Samples should come from the **same distribution**

Sample size must be **sufficiently large ( $\geq 30$ )**

Let's see CLT in action by simulation - [Link to external site](#)

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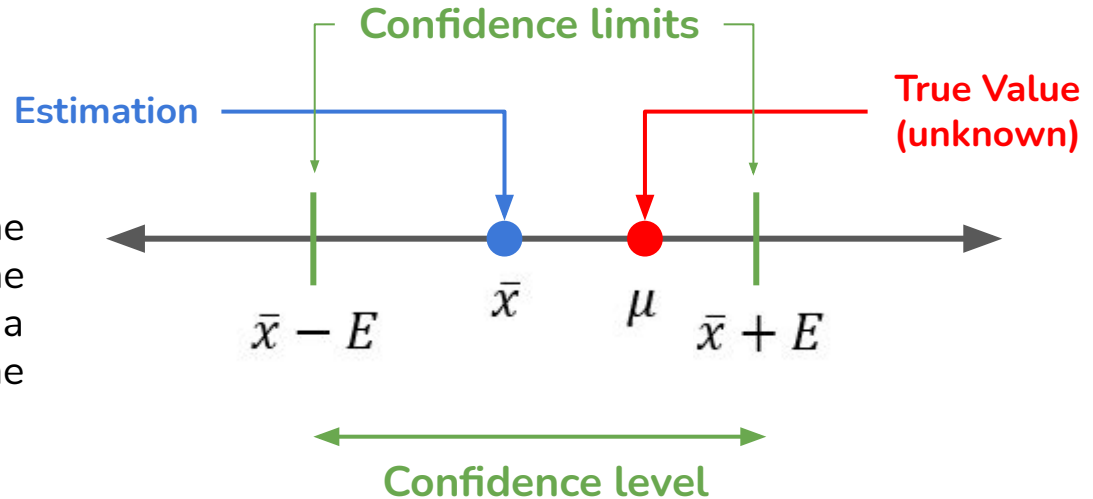
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# Confidence interval

Confidence interval provides an interval, or a range of values, which is expected to cover the true unknown parameter.



The upper and lower limits of the interval are determined using the distribution of the sample mean and a multiplier which specifies the 'confidence'

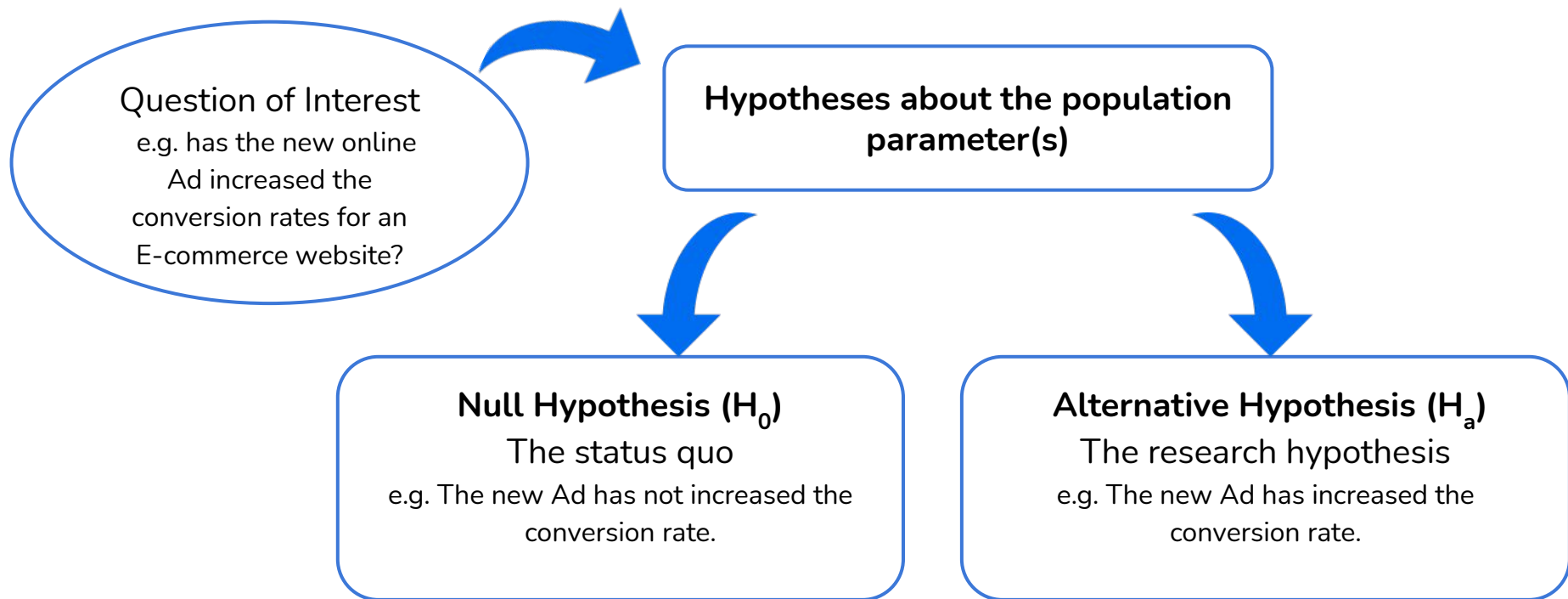


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# Introduction to Hypothesis Testing

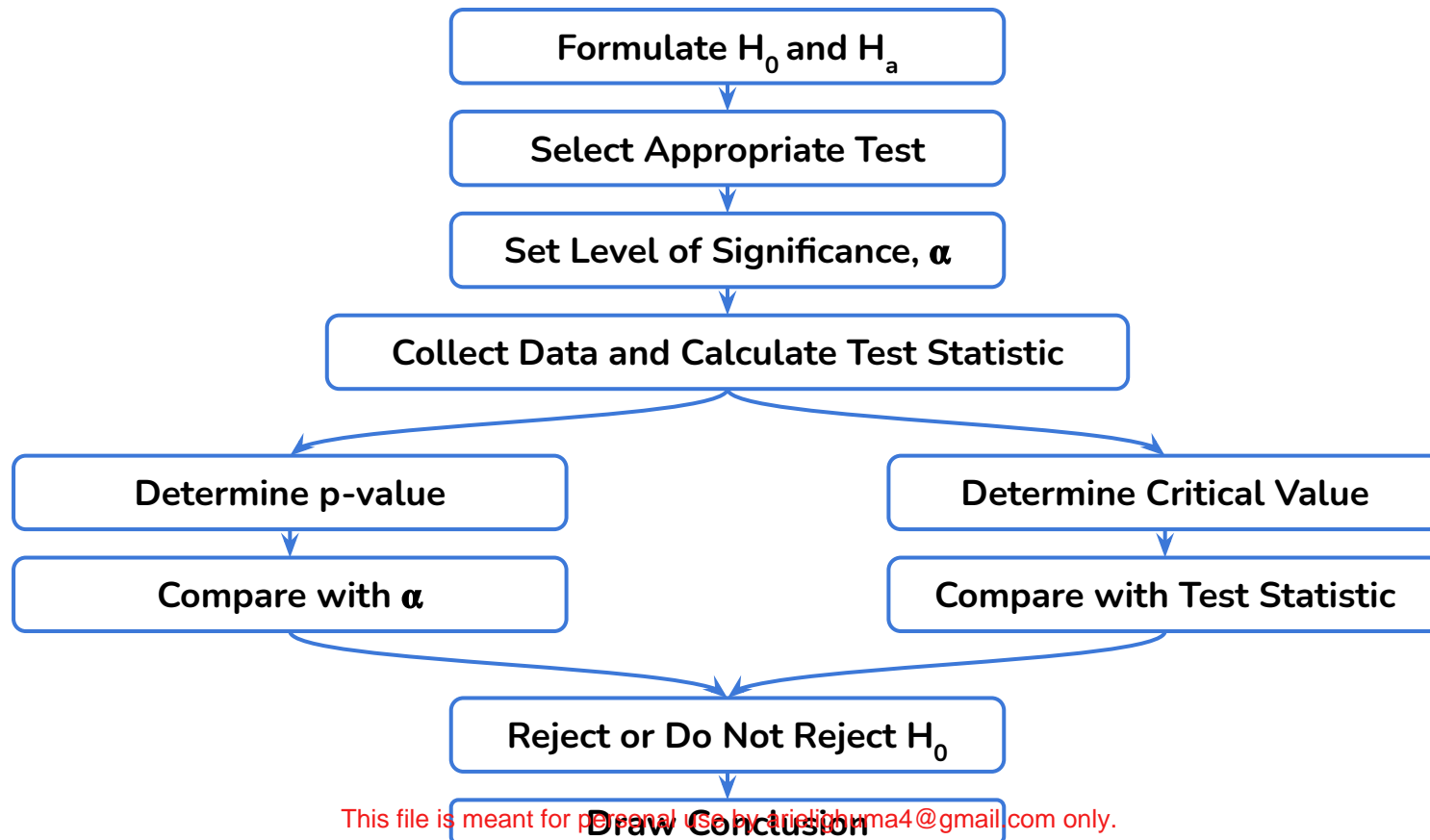


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# Hypothesis Testing Steps





# Hypothesis Formulation

## Problem Statement 1:

The store manager believes that the average waiting time for the customers of the smart supermarkets at checkouts has become worse than 15 minutes. Formulate the hypothesis.

$$H_0: \mu = 15$$

$$H_a: \mu > 15$$

## Problem Statement 2:

A pharmaceutical company has developed an improved drug. The company claims that it takes less than 12 minutes for the drug to enter in the patient's bloodstream. Formulate the hypothesis to convince the FDA to approve the claim.

$$H_0: \mu = 12$$

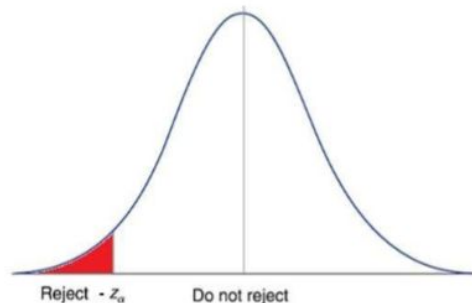
$$H_a: \mu < 12$$

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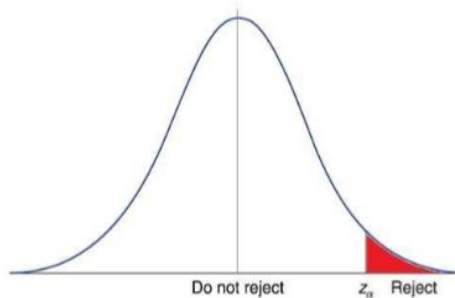
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# One-tailed vs Two-tailed Test



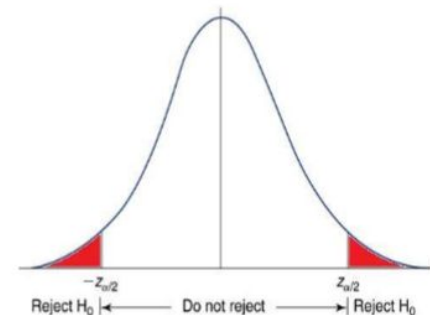
- Lower tail test.
- $H_1: \mu < \dots$

Reject  $H_0$  if the value of test statistic is too small



- Upper tail test.
- $H_1: \mu > \dots$

Reject  $H_0$  if the value of test statistic is too large



- Two tail test.
- $H_1: \mu \neq \dots$

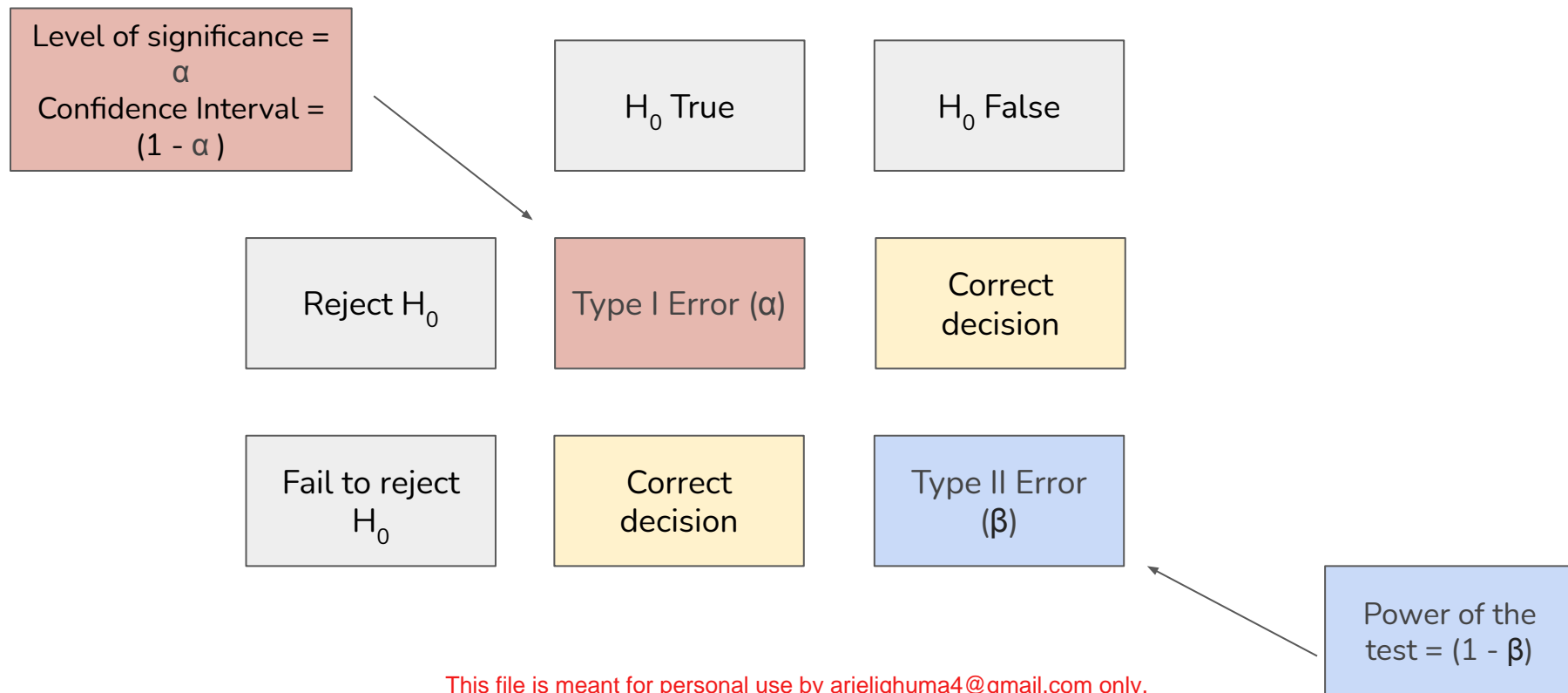
Reject  $H_0$  if the value of test statistic is either too small or too large

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# Type I and Type II errors



# Example

**Problem Statement:** The store manager believes that the average waiting time for the customers of the smart supermarkets at checkouts has become worse than 15 minutes. Formulate the hypothesis.

**Null Hypothesis ( $H_0$ ):** The average waiting time at checkouts is less than equal to 15 minutes.

**Alternate Hypothesis ( $H_a$ ):** The average waiting time at checkouts is more than 15 minutes.

**Type I error (false positive):** Reject Null hypothesis when it is indeed true. “The fact is that the average waiting time at checkout is less than equal to 15 minutes but the store manager has identified that it is more than 15 minutes”.

**Type II error (false negative):** Fail to reject Null hypothesis when it is indeed false. “The fact is that the average waiting time at checkout is more than 15 minutes but the store manager has identified that it is less than equal to 15 minutes”.

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# Let's discuss the case study!

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