Data Science with Python

simplilearn

Statistical Analysis and Business Applications

Learning Objectives

By the end of this lesson, you will be able to:

- Differentiate between statistical and non-statistical analysis
- Illustrate the two major categories of statistical analysis and their differences
- Describe statistical analysis process
- Calculate mean, median, mode, and percentile
- Describe data distribution and the various methods of representing it
- Explain types of frequencies
- Outline correlation matrix and its uses

DATA AND
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Statistics

Introduction to Statistics

Statistics is the study of the collection, analysis, interpretation, presentation, and organization of data.

COMPLEX PROBLEMS

DATA

Well-informed decision

PROBLEMS SOLVED

Introduction to Statistics

Techniques available to analyze data:

- Statistical principles
- Functions
- Algorithms

What you can do using statistical tools:

- Analyze the primary data
- Build a statistical model
- Predict the future outcome

Statistical vs. Non-Statistical Analysis

Statistical Analysis

Statistical Analysis is:

- scientific
- based on numbers or statistical values
- useful in providing complete insight of the data

Non-statistical Analysis

Non-statistical Analysis is:

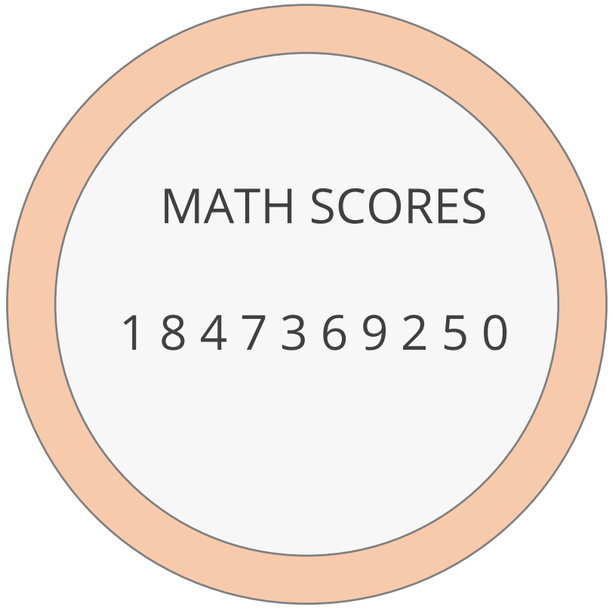
- based on generic information
- exclusive of statistical or quantitative analysis

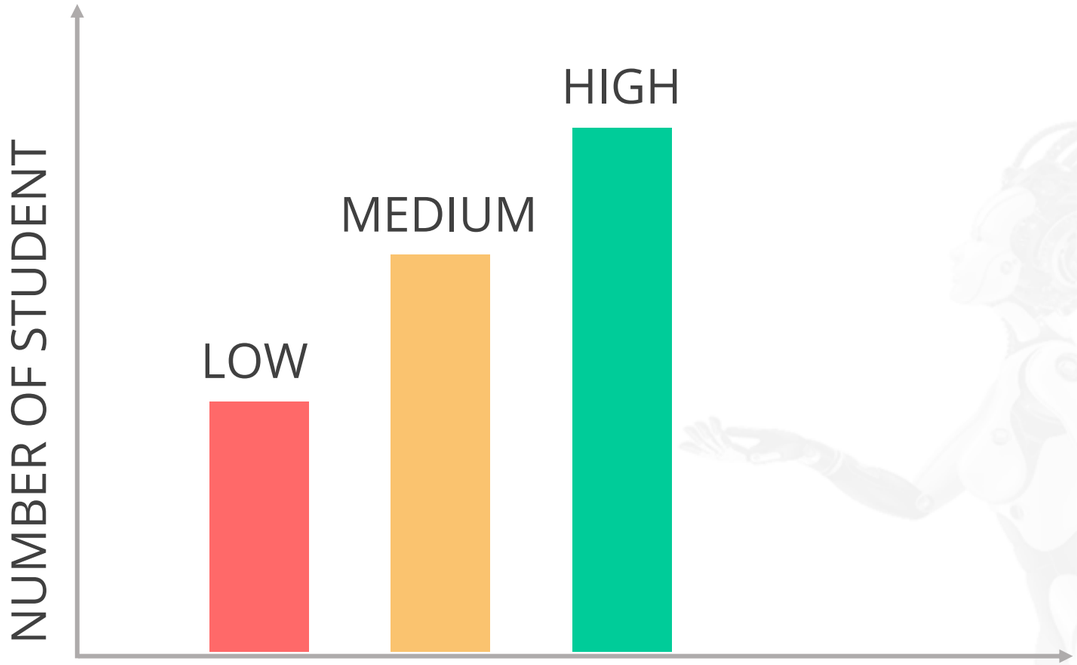
Although both forms of analysis provide results, quantitative analysis provides more insight and a clearer picture. This is why statistical analysis is important for businesses.

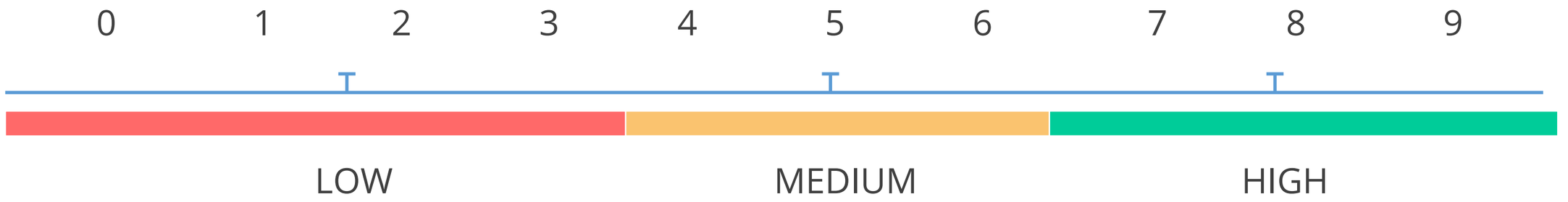
Major Categories of Statistics

There are two major categories of statistics: Descriptive analytics and inferential analytics

Descriptive analytics organizes the data and focuses on the main characteristics of the data.







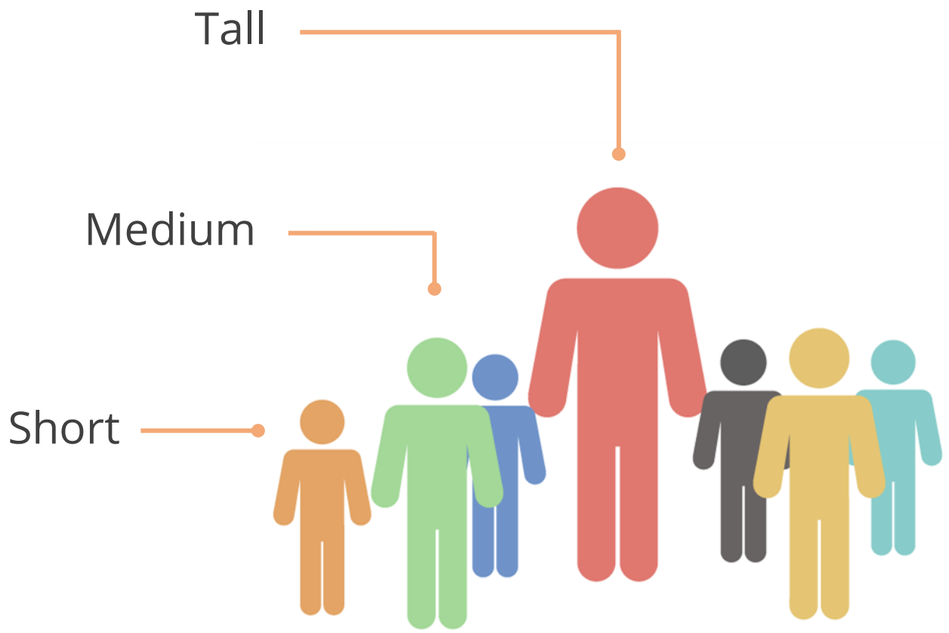
Major Categories of Statistics

- Random sample is drawn from the population
- Used to describe and make inferences about the population

Inferential analytics is valuable when it is not possible to examine each member of the population.

Major Categories of Statistics: Example

Study of height in the population



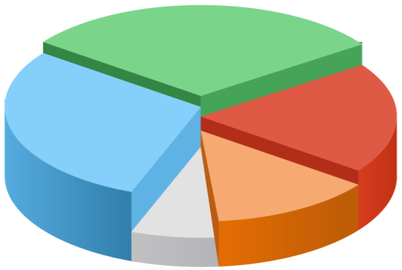
Inferential Method

Categorize height as **Tall**, **Medium**, and **Short**
Take a sample to study from the population.

Descriptive Method

Record the height of each and every person.
Provide the tallest, shortest, and average height of the population.

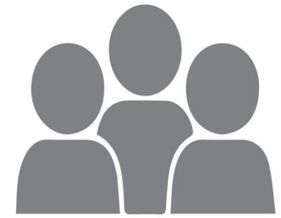
Statistical Analysis Considerations



Purpose
Clear and well-defined

Document Questions
Prepare a questionnaire in advance

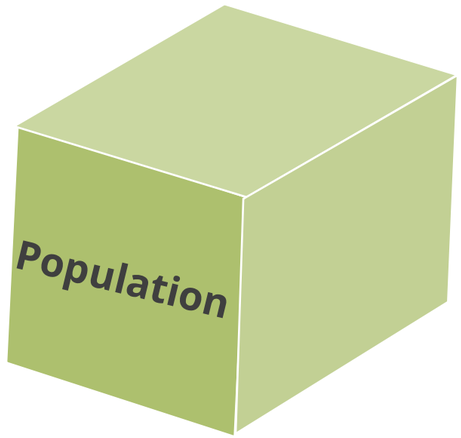
Define Population of Interest
Select population based on the purpose of analysis



Determine Sample
Based on the purpose of study

Population and Sample

A population consists of various samples. The samples together represent the population.



A sample is:

- The part/piece drawn from the population
- The subset of the population
- A random selection to represent the characteristics of the population
- The representative analysis of the entire population

Statistics and Parameters

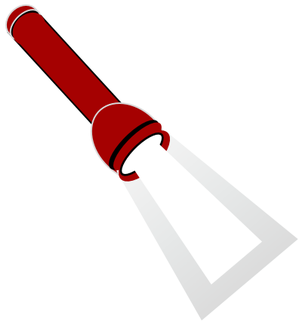
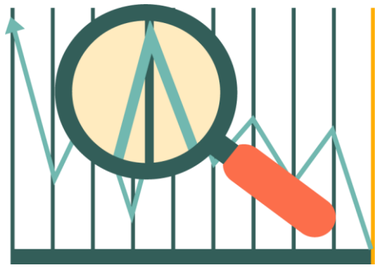
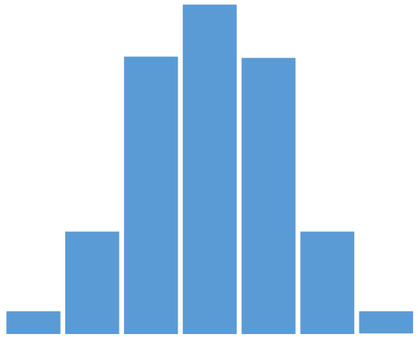
Statistics are quantitative values calculated from the sample.

Parameters are the characteristics of the population.

Sample $X_o, X_1, X_2 \ldots\ldots X_n$

	Population Parameters	Sample Statistics	Formula
Mean	μ	$\bar{x}$	$\bar{x} = \frac{1}{n}\sum x_i$
Variance	σ^2	S^2	$S^2 = \frac{1}{n-1}\sum (x_i - \bar{x})^2$
Standard Deviation	σ	S	$S = \sqrt{\frac{1}{n-1}\sum (x_i - \bar{x})^2}$

Terms Used to Describe Data

			
SEARCH	**INSPECT**	**CHARACTERIZE**	**CONCLUSION**
Search is used to find unusual data. Data that does not match the parameters.	Inspect refers to studying the shape and spread of data.	Characterize refers to determining the central tendency of the data.	Conclusion refers to preliminary or high-level conclusions about the data.

Statistical Analysis Process

There are four steps in the statistical analysis process.

Step 1: Find the population of interest that suits the purpose of statistical analysis.

Step 2: Draw a random sample that represents the population.

Step 3: Compute sample statistics to describe the spread and shape of the dataset.

Step 4: Make inferences using the sample and calculations.
Apply it back to the population.

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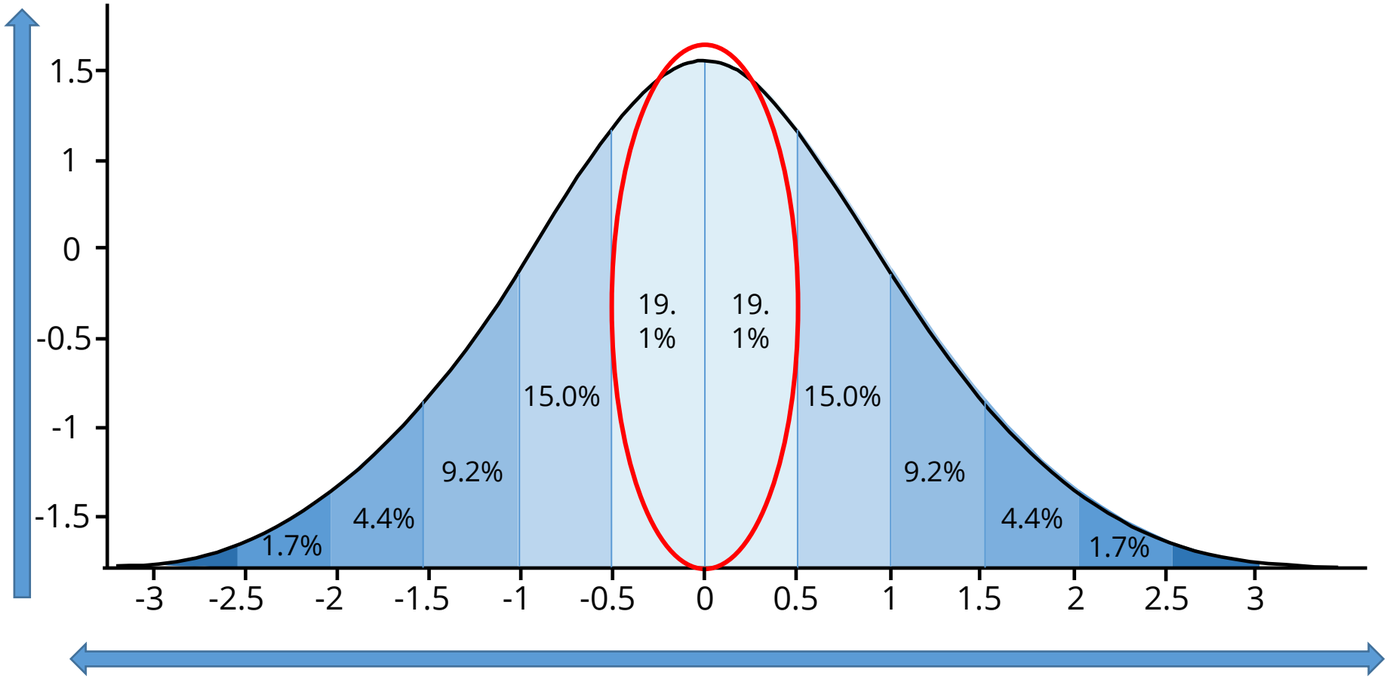
Data Distribution

Data Distribution

The collection of data values arranged in a sequence according to their relative frequency and occurrences.



Range of the data refers to minimum and maximum values.

Frequency indicates the number of occurrences of a data value.

Central tendency indicates data accumulation toward the middle of the distribution or toward the end.

Measures of Central Tendency

The measures of central tendency are Mean, Median, and Mode.

Mean is the average.
Determine the mean score of these Math scores.
1. 80
2. 70
3. 75
4. 90
5. 80
6. 78
7. 55
8. 60
9. 80

Σ [80+70+75+90+80+78+55+60+80]/9

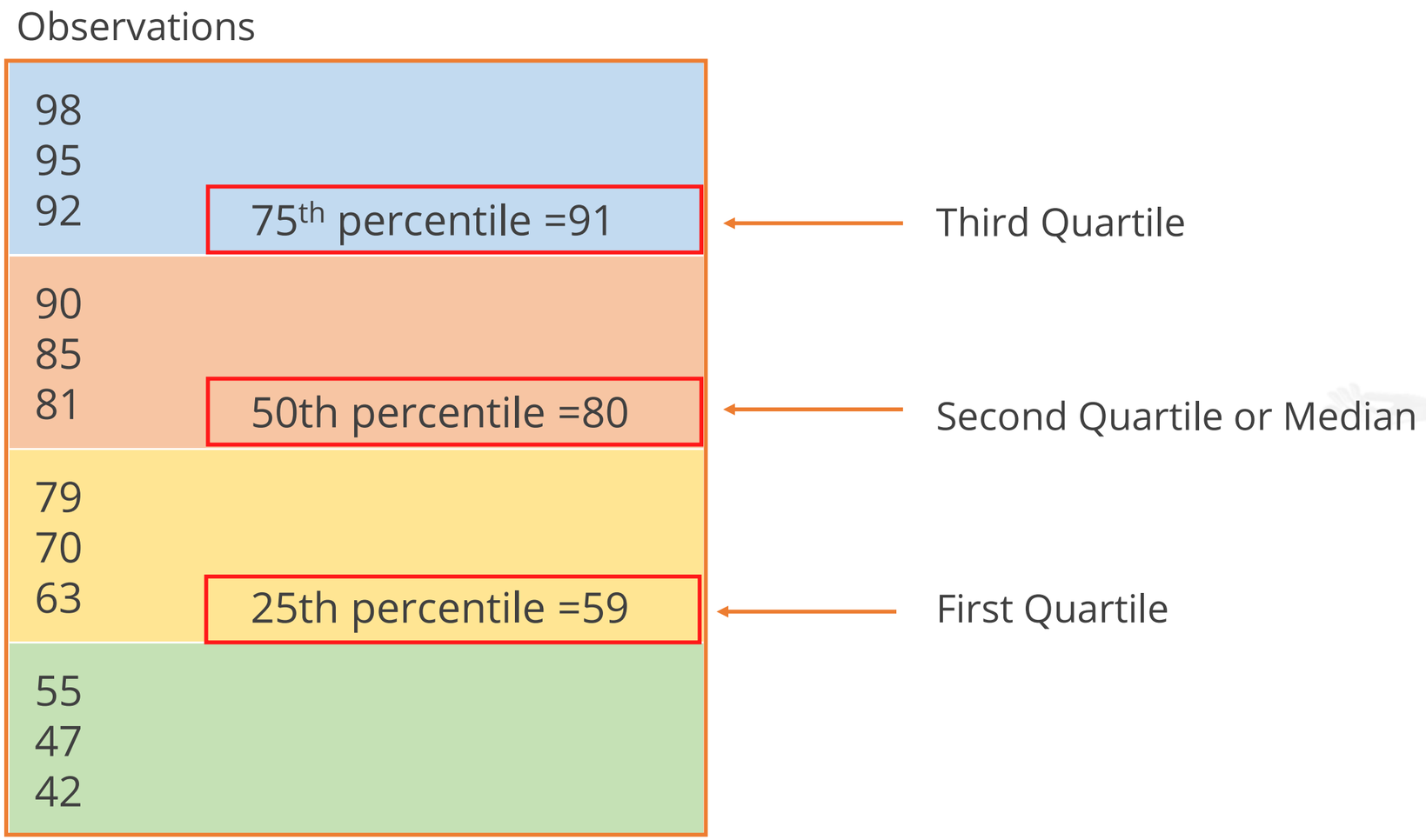
Mean = 74.22

Median is the 50th percentile.
55 60 70 75 78 80 80 80 90
Median = 78

Mode is the most frequent value.
55 60 70 75 78 80 80 80 90
Mode = 80

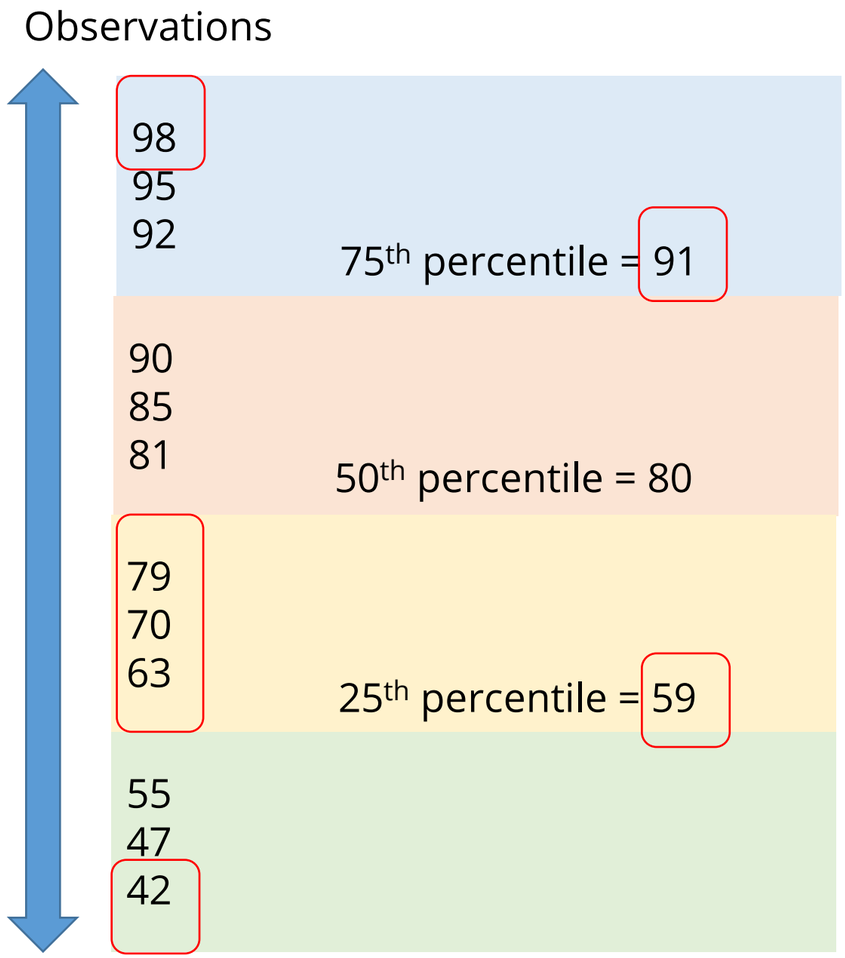
Percentiles in Data Distribution

A percentile (or a centile) indicates the value below which a given percentage of observations fall.



Dispersion

Dispersion denotes how stretched or squeezed a distribution is.



Range: The difference between the maximum and minimum values.

Inter-Quartile Range: Difference between the 25th and 75th percentiles.

Variance: Data values around the Mean. (74.75)

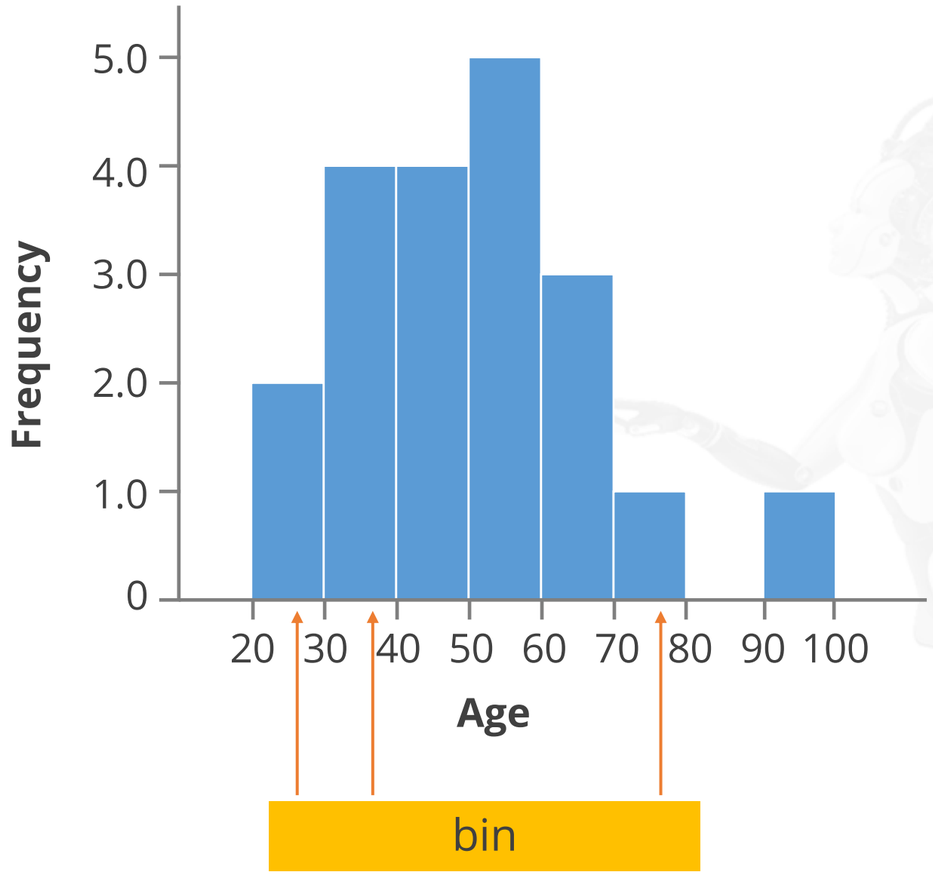
Standard Deviation: Square root of the variance measured in small units.

Histogram

Graphical representation of data distribution

Features of a Histogram:

- It was first introduced by Karl Pearson
- To construct a Histogram, **bin** the range of values
- Bins are consecutive, non-overlapping intervals of a variable
- Bins are of equal size
- The bars represent the bins
- The height of the bar represents the frequency of the values in the bin
- It helps assess the probability distribution of a variable

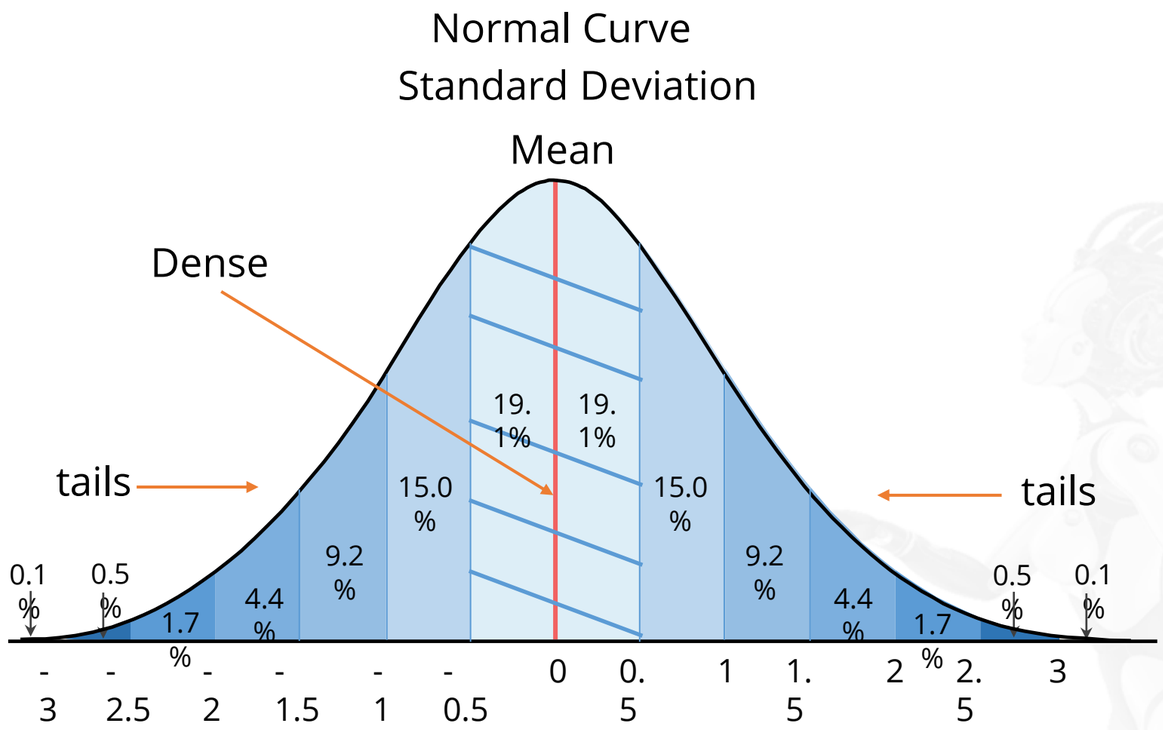


Bell Curve: Normal Distribution

The bell curve is characterized by its bell shape and two parameters, mean and standard deviation.

Bell curve is:

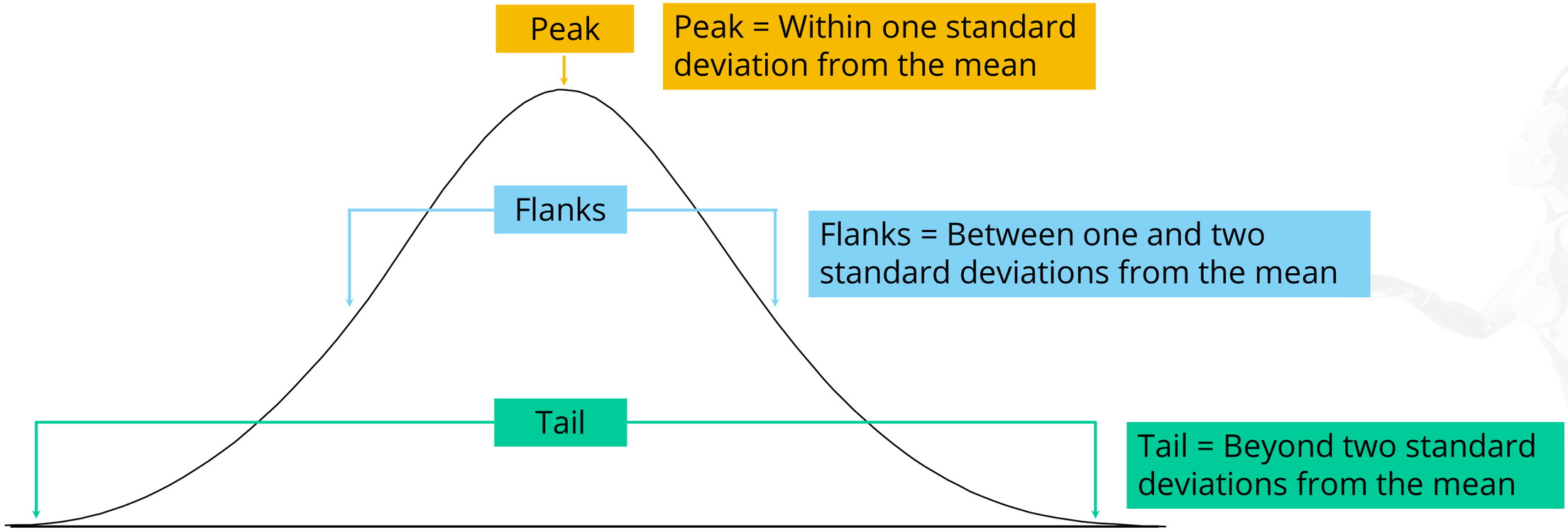
- Symmetric around the mean
- Symmetric on both sides of the center
- Having equal mean, median, and mode values
- Denser in the center compared to the tails or sides
- Defined by mean and standard deviation
- Known as the **Gaussian** curve



The Bell curve is fully characterized by the mean (μ) and standard deviation (σ).

Bell Curve

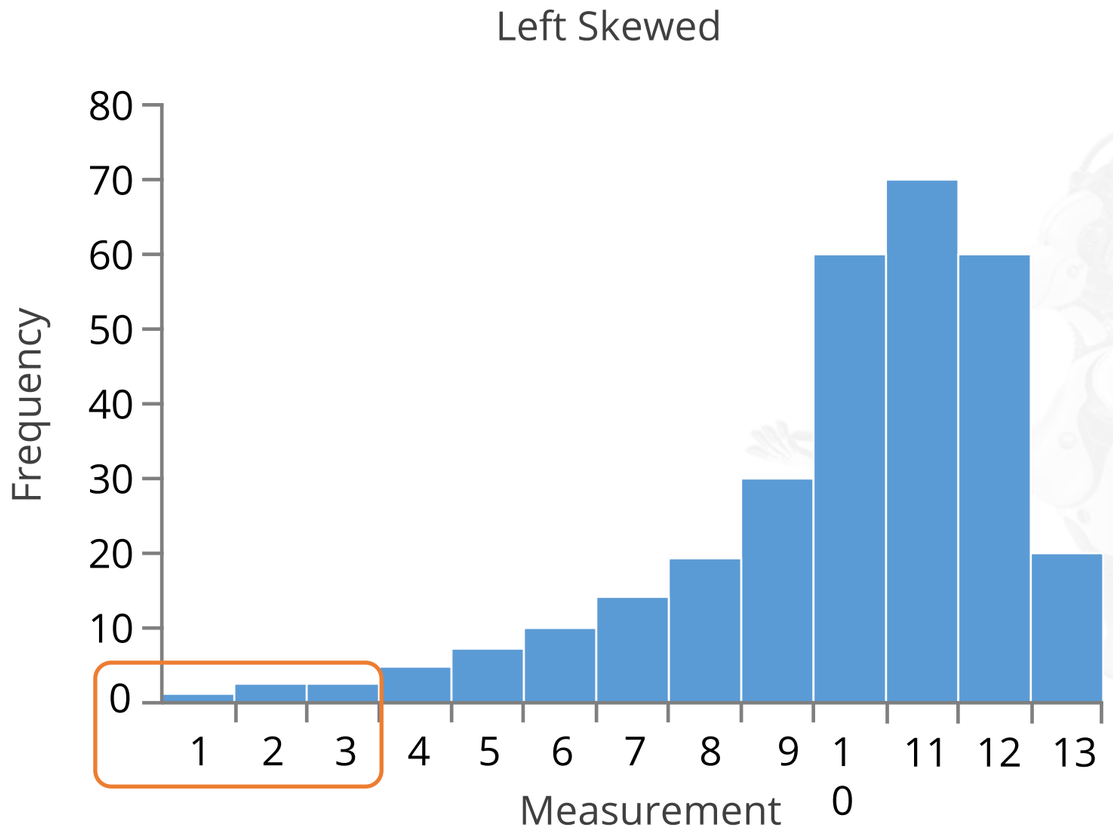
The Bell curve is divided into three parts to understand data distribution better.



Bell Curve: Left Skewed

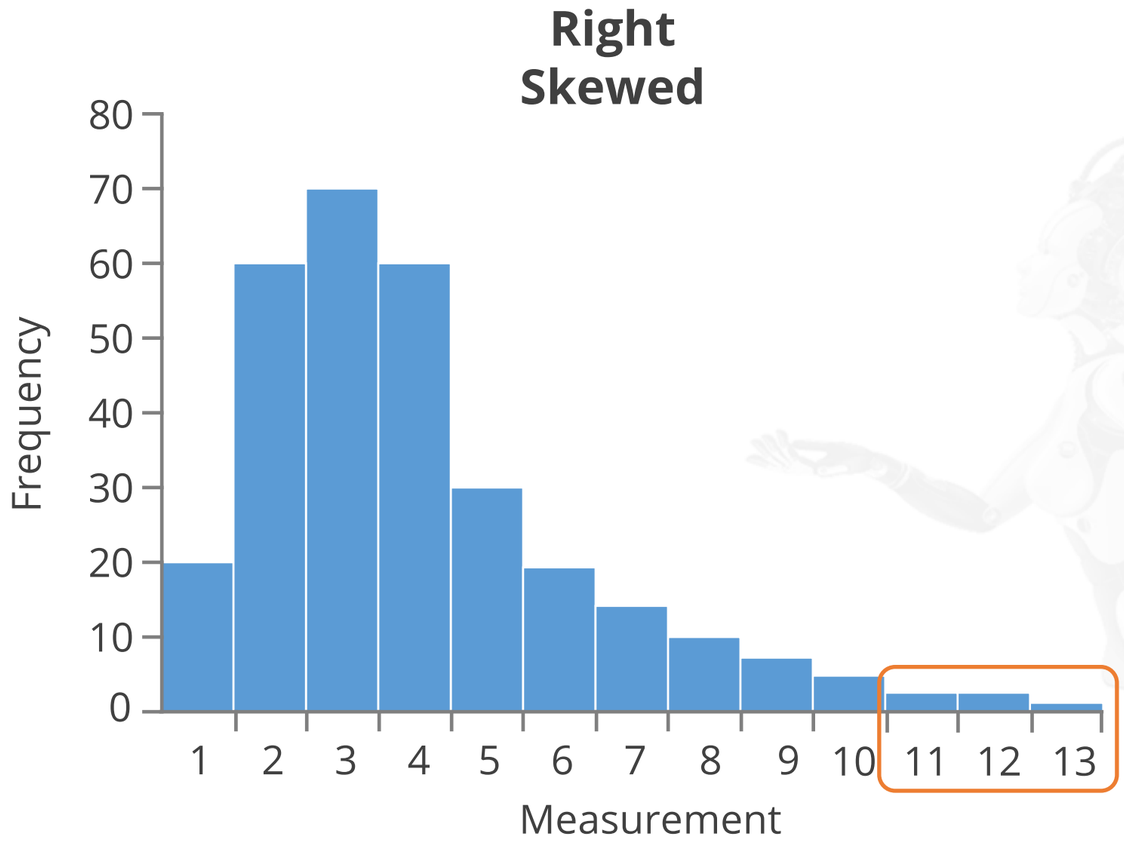
Skewed data distribution indicates the tendency of the data distribution to be more spread out on one side.

- The data is left skewed
- Mean < Median
- The distribution is negatively skewed
- Left tail contains large distributions



Bell Curve: Right Skewed

- The data is right skewed
- The distribution is positively skewed
- Mean > Median
- Right tail contains large distributions



Kurtosis

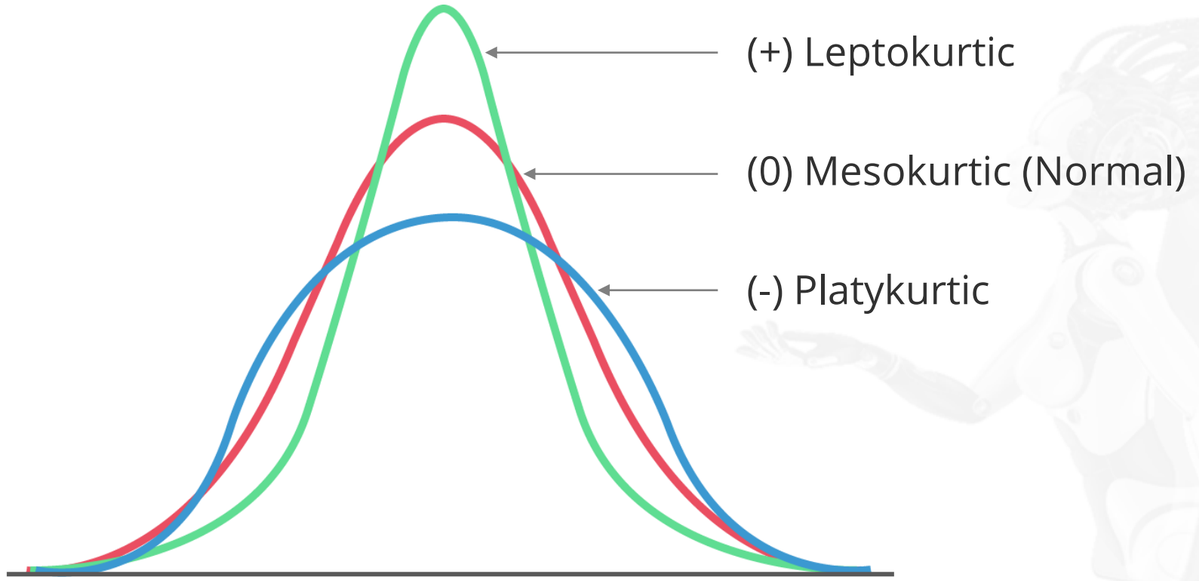
Kurtosis describes the shape of a probability distribution.

Kurtosis measures the tendency of the data toward the center or toward the tail.

Platykurtic is negative kurtosis.

Mesokurtic represents a normal distribution curve.

Leptokurtic is positive kurtosis.



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Hypothesis Testing

Hypothesis Testing

Hypothesis testing is an inferential statistical technique that determines if a certain condition is true for the population.

Alternative Hypothesis (H1)	Null Hypothesis (H0)
A statement that has to be concluded as true.	A statement of **no effect** or **no difference**.
It's a research hypothesis.	It's the logical opposite of the alternative hypothesis.
It needs significant evidence to support the initial hypothesis.	It indicates that the alternative hypothesis is incorrect.
If the alternative hypothesis garners strong evidence, reject the null hypothesis.	Weak evidence of alternative hypothesis indicates that the null hypothesis has to be accepted.

Hypothesis Testing: Error Types

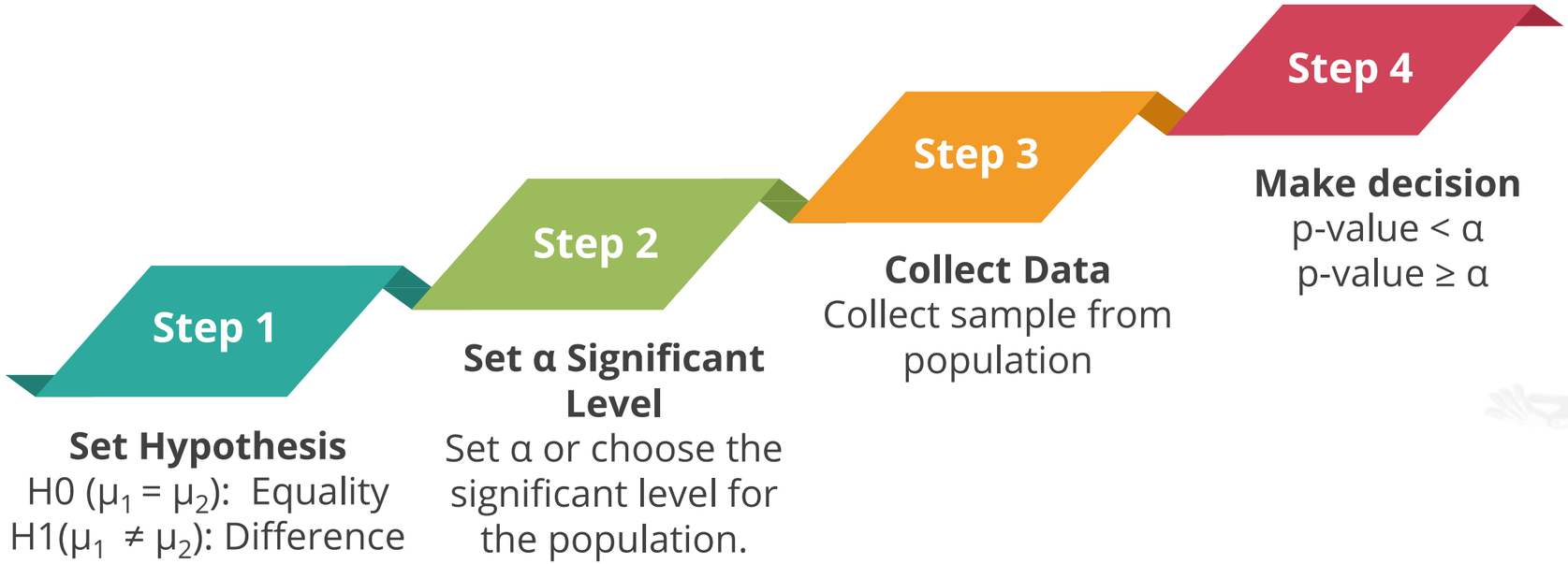
Representation of decision parameters using null hypothesis

Type I Error (α)	• Rejects the null hypothesis when it is true • The probability of making Type I error is represented by α
Type II Error (β)	• Fails to reject the null hypothesis when it false • The probability of making Type II error is represented by β
p-value	• The probability of observing extreme values • Calculated from collected data

Decision	H0 is True	H0 is False
Fail to Reject Null	Correct	Type II Error
Reject Null	Type I Error	Correct

Hypothesis Testing: Process

There are four steps in the hypothesis testing process.



Reject the null hypothesis if p-value < α
Fail to reject the null hypothesis if p-value ≥ α

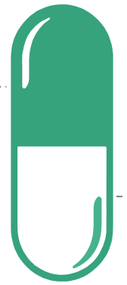
Perform Hypothesis Testing

An example of clinical trials data analysis.

Company A

Company B

Null Hypothesis: Both medicines are equally effective.



Alternative Hypothesis: Both medicines are NOT equally effective.

Data for Hypothesis Testing

There are three types of data on which you can perform hypothesis testing.

Continuous Data

Evaluate the mean, median, standard deviation, or variance.

Binomial Data

Evaluate the percentage and general classification of data.

Poisson Data

Evaluate rate of occurrence or frequency.

Types of Variables

There are three types of variables in categorical data.

Nominal Variables

- Values with no logical ordering
- Variables are independent of each other
- Sequence does not matter

Ordinal Variables

- Values are in logical order
- Relative distance between two data values is not clear

Association

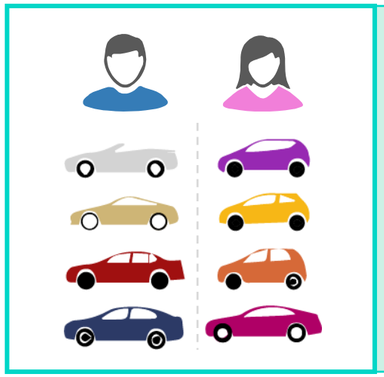
Two variables are associated or independent of each other.

85%	15%	68%	32%
85%	15%	95%	55%

Chi-Square Test

It is a hypothesis test that compares the observed distribution of your data to an expected distribution of data.

Test of Association:
To determine whether one variable is associated with a different variable. For example, determine whether the sales for different cellphones depend on the city or country where they are sold.



Test of Independence:
To determine whether the observed value of one variable depends on the observed value of a different variable. For example, determine whether the color of the car that a person chooses is independent of the person's gender.

Test is usually applied when there are two categorical variables from a single population.

Chi-Square Test: Example

Null Hypothesis

- There is no association between gender and purchase.
- The probability of purchase does not change for 500 dollars or more whether female or male.

Alternative Hypothesis

- There is association between gender and purchase.
- The probability of purchase over 500 dollars is different for female and male.

	<$500	>$500
fo	.55	.45
fo	.75	.25

Types of Frequencies

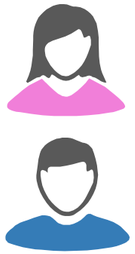
Expected and observed frequencies are the two types of frequencies.

Expected Frequencies (fe)

The cell frequencies that are expected in a bivariate table if the two tables are statistically independent.

Observed Frequencies (fo)

- There is association between gender and purchase.
- The probability of purchase over 500 dollars is different for female and male.



	Purchases	
	<$500	>$500
fo	.55	.45
fo	.75	.25

No Association
Observed Frequency = Expected Frequency

Association
Observed Frequency ≠ Expected Frequency

Features of Frequencies

The formula for calculating expected and observed frequencies using Chi Square:

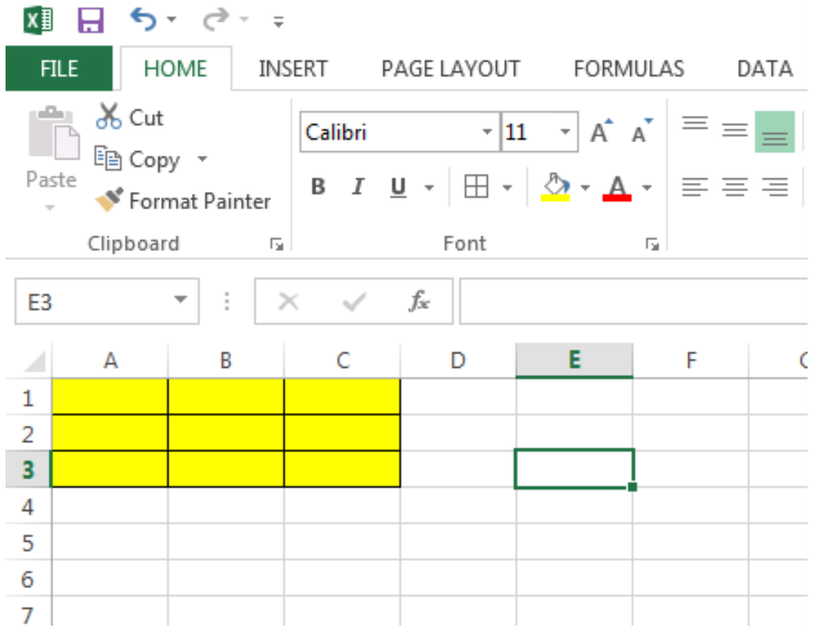
$$\sum \frac{(f_e - f_o)^2}{f_e}$$

Features of Expected and Observed frequencies:

- Requires no assumption of the underlying population
- Requires random sampling

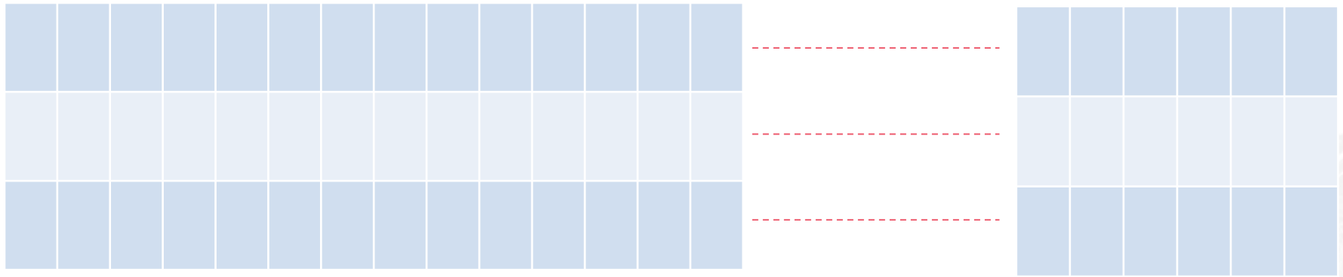
Correlation Matrix

A Correlation matrix is a square matrix that compares large number of variables.



(0,0)	(0,1)	(0,2)
(1,0)	(1,1)	(1,2)
(2,0)	(2,1)	(2,2)

3 × 3 matrix (simple square matrix)



Correlation matrix – a square matrix

n × n Matrix

(very large number of rows and columns)

Correlation coefficient measures the extent to which two variables tend to change together.

The coefficient describes both the strength and direction of the relationship.

Correlation Matrix

Pearson product moment correlation	It evaluates the linear relationship between two continuous variables. Linear relationship means that a change in one variable results in a proportional change in the other.
Spearman rank order correlation	It evaluates the monotonic relationship between two continuous or ordinal variables. • Monotonic relationship means that the variables tend to change together though not necessarily at a constant rate. • The correlation coefficient is based on the ranked values for each variable rather than the raw data.

Correlation Matrix: Example

An example of a correlation matrix calculated for a stock market.

U10 =CORREL($C$9:$C$78,B$9:B$78)

	T	U	V	W	X	Y	Z
8	Correlation	EQUITY 1	EQUITY 2	FX FORWARD 1	FX FORWARD 2	BOND 1	BOND 2
9	EQUITY 1	1.00	0.38	0.20	0.45	- 0.17	- 0.12
10	EQUITY 2	0.38	1.00	0.54	0.51	- 0.20	0.12
11	FX FORWARD 1	0.20	0.54	1.00	0.35	- 0.14	0.16
12	FX FORWARD 2	0.45	0.51	0.35	1.00	- 0.11	- 0.09
13	BOND 1	- 0.17	- 0.20	- 0.14	- 0.11	1.00	0.03
14	BOND 2	- 0.12	0.12	0.16	- 0.09	0.03	1.00

A correlation matrix that is calculated for the stock market will probably show the short-term, medium-term, and long-term relationship between data variables.

Inferential Statistics

Inferential statistics uses a random sample from the data to make inferences about the population.

Inferential statistics can be used only under the following conditions:

- A complete list of the members of the population is available.
- A random sample has been drawn from the population.
- Using a pre-established formula, you determine that the sample size is large enough.

Inferential statistics can be used even if the data does not meet the criteria.

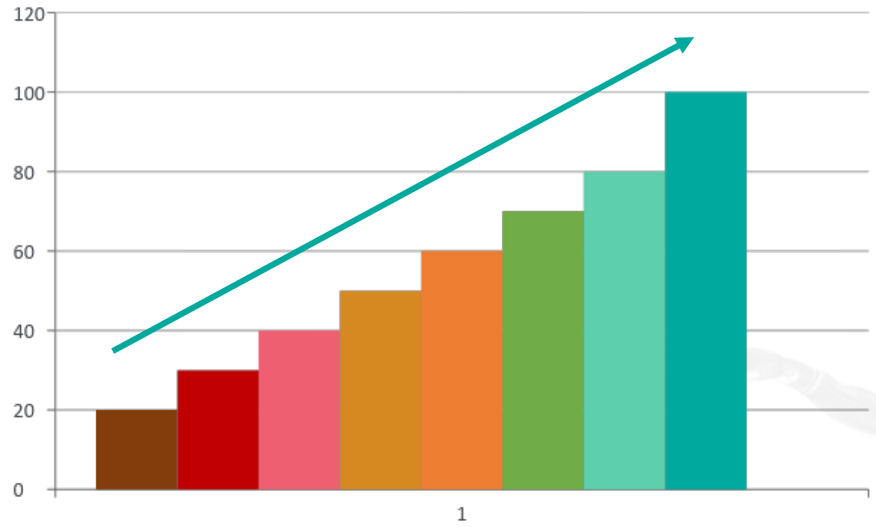
- It can help determine the strength of the relationships within the sample.
- If it is very difficult to obtain a population list and draw a random sample, do the best you can with what you have.

Applications of Inferential Statistics

Inferential Statistics has its uses in almost every field, such as business, medicine, data science, and so on.

Inferential Statistics

- Is an effective tool for forecasting
- Is used to predict future patterns



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Knowledge Check

Knowledge Check

1

What does frequency indicate?

a. Range of the values present in the dataset

b. Number of occurrences of a particular value in a dataset

c. How spread out the data is

d. Size of the sample drawn from a population

Knowledge Check

1

What does frequency indicate?

a. Range of the values present in the dataset

b. Number of occurrences of a particular value in a dataset

c. How spread out the data is

d. Size of the sample drawn from a population

The correct answer is **b**

Frequency indicates the number of occurrences of a particular value in a dataset.

Knowledge Check

2

In Chi-Square test, there is no association of variables if:

a. Observed Frequency ≠ Expected Frequency

b. Observed Frequency = Expected Frequency

c. Independent of observed frequencies

d. Independent of expected frequencies

Knowledge Check

2

In Chi-Square test, there is no association of variables if:

a. Observed Frequency ≠ Expected Frequency

b. Observed Frequency = Expected Frequency

c. Independent of observed frequencies

d. Independent of expected frequencies

The correct answer is **b**

Observed Frequency = Expected Frequency indicates no association.

Knowledge Check

3

Which of the following is true for a normal distribution?

a. Mean and median are equal

b. Mean and mode are equal

c. Mean, median, and mode are equal

d. Mode and median are equal

Knowledge Check

3

Which of the following is true for a normal distribution?

a. Mean and median are equal

b. Mean and mode are equal

c. Mean, median, and mode are equal

d. Mode and median are equal

The correct answer is **c**

For a normal distribution, mean, median, and mode are equal.

Knowledge Check

4

If a sample of five boxes weigh 90, 135, 160, 115, and 110 pounds, what will be the median weight of this sample?

a. 160

b. 115

c. 90

d. 135

The correct answer is **b**

Arrange in a sequential order and the middle number will be the median. If the set of numbers is even, then take the average or mean of the two numbers in the middle.

Knowledge Check

4

If a sample of five boxes weigh 90, 135, 160, 115, and 110 pounds, what will be the median weight of this sample?

a. 160

b. 115

c. 90

d. 135

Knowledge Check

5

Identify the parameters that characterize a bell curve. Select all that apply.

a. Variance

b. Mean

c. Standard deviation

d. Range

Knowledge Check

5

Identify the parameters that characterize a bell curve. Select all that apply.

a. Variance

b. Mean

c. Standard deviation

d. Range

The correct answer is **b and c**

Bell Curve is completely characterized by mean and standard deviation.

Knowledge Check

6

Identify the hypothesis decision rules. Select all that apply.

a. Reject the null hypothesis if *p*-value < α

b. Is independent of *p*-value

c. Fail to reject the null hypothesis if *p*-value ≥ α

d. Is independent of α

Knowledge Check

6

Identify the hypothesis decision rules. Select all that apply.

a. Reject the null hypothesis if *p*-value < α

b. Is independent of *p*-value

c. Fail to reject the null hypothesis if *p*-value ≥ α

d. Is independent of α

The correct answer is **a and c**

A hypothesis decision rule:

- Reject the null hypothesis if *p*-value < α
- Fail to reject the null hypothesis if *p*-value ≥ α

Key Takeaways

You are now able to:

- Differentiate between statistical and non-statistical analysis
- Illustrate the two major categories of statistical analysis and their differences
- Describe statistical analysis process
- Calculate mean, median, mode, and percentile
- Describe data distribution and the various methods of representing it
- Explain types of frequencies
- Outline correlation matrix and its uses

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Thank You