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Continuing Education Academy
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STAT 112

CH. 1

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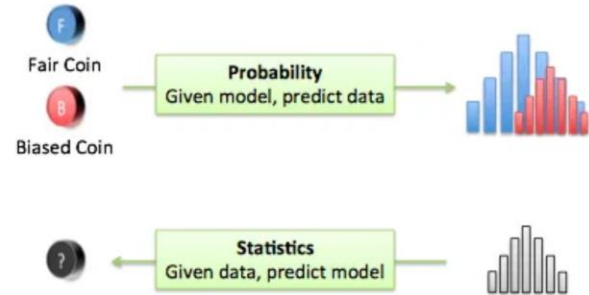
THE NATURE OF PROBABILITY & STATISTICS

طبيعة الاحتمالات والإحصاء

This chapter introduces the fundamental concepts of probability and statistics, providing the foundation for statistical thinking and analysis.

We will explore key definitions, types of statistics, variables, measurement levels, sampling techniques, and proper use of statistical methods.

Probability & Statistics



Key Statistical Definitions



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Statistics الإحصاء

The science of collecting, analyzing, and drawing conclusions from data.

Example: Analyzing patient recovery times after a new treatment to determine its effectiveness.

Variable المتغير

A characteristic that can assume different values.

Example: Blood pressure, height, gender, or educational level.

Random Variable المتغير العشوائي

Variables with values determined by chance.

Example: Number of patients arriving at an emergency room in an hour.

Population المجتمع

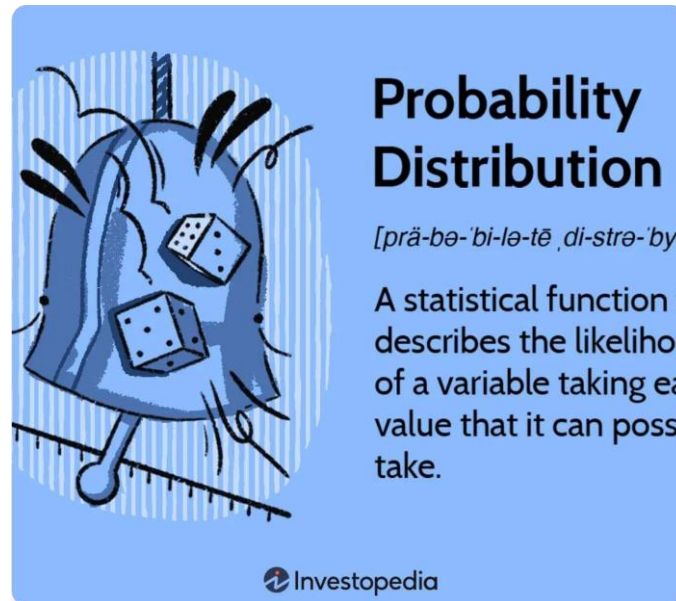
All subjects being studied.

Example: All diabetic patients in Saudi Arabia.

Sample العينة

A group selected from a population.

Example: 200 randomly selected diabetic patients from hospitals in Riyadh.



1. In order to study the response times for emergency **988 calls** in Jeddah, **50 calls** are selected randomly over a six-month period and the response times are recorded.

- Population:** All emergency calls (988).

- Sample:** 50 calls.

2. **1500 listeners** to a talk radio program of various types are selected.

- Population:** All listeners to the radio program.

- Sample:** 1500 listeners.

Biostatistics: Application in Biological Sciences



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What is Biostatistics?

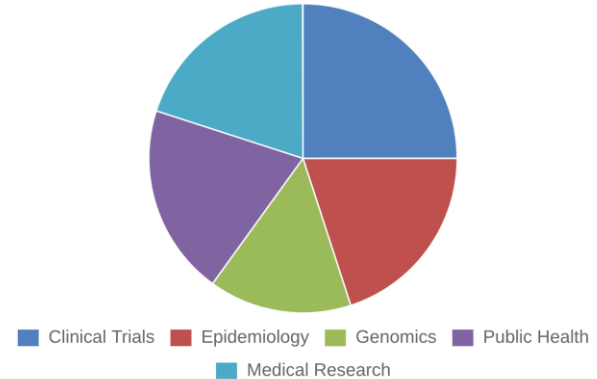
Biostatistics is the application of statistical tools and concepts in the field of biological sciences and medicine.

It involves the collection, analysis, and interpretation of data related to living organisms, health, and disease.

Sources of Biostatistical Data

-  Medical records and day-to-day logs of healthcare activities
Example: Patient electronic health records showing treatment history and outcomes
-  Surveys and questionnaires from patients or healthcare providers
Example: Patient satisfaction surveys or quality of life assessments
-  Experiments such as clinical trials and medical interventions
Example: Randomized controlled trial comparing a new drug to standard treatment
-  External sources like published medical reports and research literature
Example: Meta-analysis of published studies on diabetes treatments

Areas of Biostatistics Application



Biostatistics combines statistical methods with biological and medical research to improve healthcare outcomes and advance scientific knowledge.

Types of Statistics



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Descriptive Statistics

الإحصاء الوصفي

Definition:

Collection, organization, summarization, and presentation of data.

Example: Calculating the average blood pressure of 100 patients.

Keywords:

Is, was, are, were, average, mean, median, mode

Example: "The average recovery time is 5 days."

Methods:

Tables, graphs, measures of central tendency

Example: Creating a histogram showing the distribution of patient ages.

Inferential Statistics

الإحصاء الاستدلالي

Definition:

Generalizing from samples to populations, performing estimations and hypothesis tests.

Example: Using a sample to predict treatment effectiveness for an entire population.

Keywords:

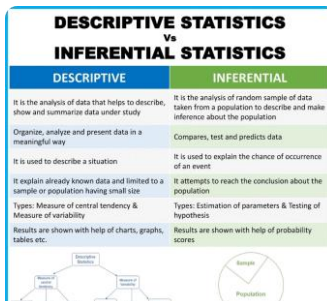
Will be, would be, can be, could be

Example: "We predict that 75% of patients will respond to this treatment."

Methods:

Hypothesis testing, confidence intervals, regression

Example: Testing if a new drug significantly reduces cholesterol levels.



- a) In the year **2020**, 148 million Americans **will** be enrolled in an HMO.
→ *(Inferential)*
- b) Nine out of ten on-the-job fatalities are men.
→ *(Descriptive)*
- c) Expenditures for the cable industry were **\$5.66 billion** in **1996**.
→ *(Descriptive)*
- d) The **median household income** for people aged **25–34** is **\$35,888**.
→ *(Descriptive)*
- e) Drinking decaffeinated coffee **can** raise cholesterol levels by **7%**.
→ *(Inferential)*
- f) The national **average annual medicine expenditure per person** is **\$1052**.
→ *(Descriptive)*
- g) Experts say that mortgage rates may **soon** hit bottom.
→ *(Inferential)*

Types of Variables



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Qualitative (Categorical)

المتغير الوصفي

Variables that can be placed into distinct categories according to some characteristic or attribute.

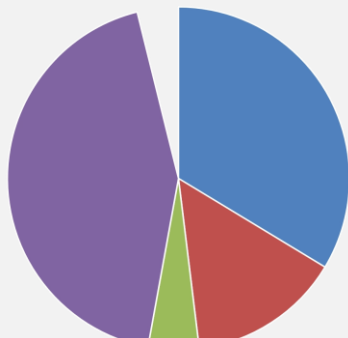
Examples:

Color: Red, Green, Blue

Nationality: Saudi, Kuwaiti, Omani

Blood Type: A, B, AB, O

Example: Blood Type Distribution



Quantitative (Numerical)

المتغير الكمي

Variables that are numerical in nature and can be ordered or ranked.

Examples:

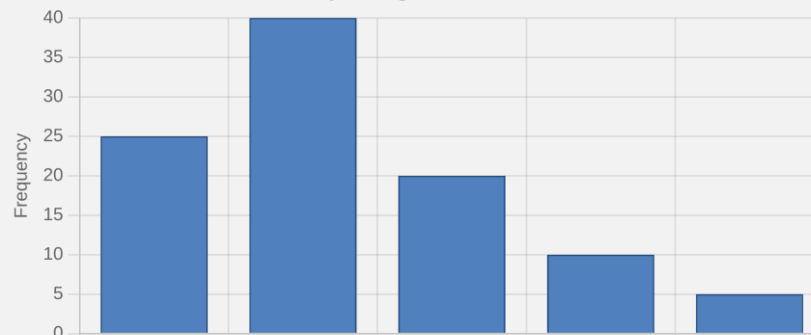
Age: 5 years, 10 years

Height: 160 cm, 175 cm

Weight: 60 kg, 75 kg

Salary: 10,000 Riyal, 15,000 Riyal

Example: Age Distribution



- **a. Number of bicycles sold in 1 year by a large sporting goods Store.** (This is a count.)
- **c. Times it takes to cut a lawn.** (This is a measurement of time.)
- **d. Capacity in cubic feet of six truck beds.** (This is a measurement of volume.)
- **f. Weights of fish caught in Lake George.** (This is a measurement of mass/weight.)
- **b. Colors of baseball caps in a store.** (This is an attribute/category.)
- **e. Classification of children in a day-care center (infant - toddler, preschool).** (This is an attribute/category.)
- **g. Marital statuses of faculty members in a large university.** (This is an attribute/category.)

Variable	Classification	Variable	Classification
a	Quantitative	e	Qualitative
b	Qualitative	f	Quantitative
c	Quantitative	g	Qualitative
d	Quantitative		

Random Variables



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What is a Random Variable?

A random variable is a quantitative variable whose obtained values arise as a result of chance factors, so that they cannot be exactly predicted in advance.

Discrete Random Variable

Possesses gaps or interruptions in the values that it can assume. Values are typically countable.

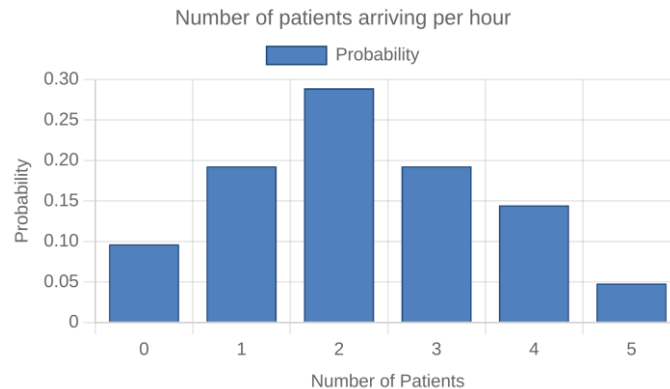
Examples: Number of daily hospital admissions, number of children in a family, number of bacteria in a sample

Continuous Random Variable

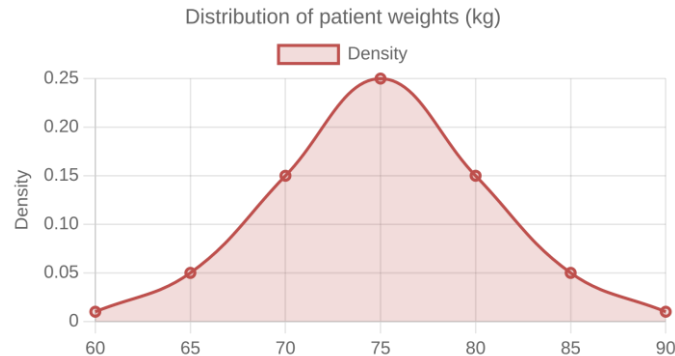
Does not possess gaps or interruptions in the values that it can assume. Values are on a continuous scale.

Examples: Height, weight, blood pressure, temperature, circumference of the skull

Discrete Random Variable Example



Continuous Random Variable Example



Variable	Classification	Explanation
a. Number of doughnuts sold each day by Doughnut Heaven.	Discrete	This is a count of items. The number of doughnuts can only take on whole number values (e.g., 50, 51, 52), not values like 50.5.
b. Water temperatures of six swimming pools in Pittsburgh on a given day.	Continuous	This is a measurement. Temperature can take on any value within a given range (e.g., 75.1°, 75.15°), limited only by the precision of the measuring instrument.
c. Weights of cats in a pet shelter.	Continuous	This is a measurement of weight. Weight can take on any value within a given range (e.g., 8.2 lbs, 8.245 lbs).
d. Lifetime (in hours) of 12 flashlight batteries.	Continuous	This is a measurement of time. Time can take on any value within a given range (e.g., 5.5 hours, 5.512 hours).
e. Number of cheeseburgers sold each day by a hamburger stand on a college campus.	Discrete	This is a count of items. The number of cheeseburgers must be a whole number.
f. Number of DVDs rented each day by a video store.	Discrete	This is a count of items. The number of DVDs must be a whole number.
g. Capacity (in gallons) of six reservoirs in Jefferson County.	Continuous	This is a measurement of volume/capacity. It can take on any value within a range (e.g., 1000 gallons, 1000.5 gallons).

Levels of Measurement - Qualitative



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Nominal

Classifies data into mutually exclusive categories in which no order or ranking can be imposed.

Examples: Car color, Nationality, Blood type, Gender

-  Blood type: A, B, AB, O (no inherent order)
-  Patient nationality: Saudi, Egyptian, Jordanian
-  Gender: Male (0), Female (1)

Ordinal

Classifies data into categories that can be ranked; however, precise differences between the ranks do not exist.

Examples: Educational level, Pain level, Customer satisfaction

-  Educational level: Elementary, Middle, High School
-  Pain level: Mild (1), Moderate (2), Severe (3)
-  Patient satisfaction: Very dissatisfied (1) to Very satisfied (5)

THE FOUR LEVELS OF MEASUREMENT:

	Nominal	Ordinal	Interval	Ratio
Categorizes and labels variables	✓	✓	✓	✓
Ranks categories in order		✓	✓	✓
Has known, equal intervals			✓	✓
Has a true or meaningful zero				✓

Levels of Measurement - Quantitative



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Interval

Ranks data with precise differences between units of measure, but there is no meaningful zero.

Examples: Temperature, IQ score, Calendar dates

🌡 Temperature: 0°C doesn't mean absence of temperature (0°C = 32°F)

🧠 IQ scores: A score of 0 doesn't mean no intelligence

📅 Calendar years: Year 0 is arbitrary, not "no time"

فترة

Ratio

Possesses all the characteristics of interval measurement, plus there exists a true zero.

Examples: Age, Weight, Height, Time, Salary

🏋 Weight: 0 kg means truly no weight

📏 Height: 0 cm means no height

⌚ Time: 0 seconds means no time has elapsed

نسبة

Scales of Measurement

Data	Nominal	Ordinal	Interval	Ratio
Labeled	✓	✓	✓	✓
Meaningful Order	✗	✓	✓	✓
Measurable Difference	✗	✗	✓	✓
True Zero Starting Point	✗	✗	✗	✓

Variable	Classification	Explanation
a. Pages in the city of Cleveland telephone book.	Ratio	The data is numerical, differences are meaningful, and a true zero point exists (0 pages means no book/pages). Ratios are also meaningful (e.g., 200 pages is twice as many as 100 pages).
b. Rankings of tennis players.	Ordinal	The data is categorical, and the categories have a meaningful order (1st is better than 2nd), but the differences between ranks are not uniform or meaningful (the difference between rank 1 and 2 isn't necessarily the same as between 10 and 11).
c. Weights of air conditioners.	Ratio	The data is numerical, differences are meaningful, and a true zero point exists (0 weight means no air conditioner). Ratios are meaningful.
d. Temperatures inside 10 refrigerators.	Interval	The data is numerical, and differences are meaningful, but there is no true zero point (0°F or 0°C doesn't mean "no temperature"). Ratios are not meaningful (e.g., 40°F is not twice as warm as 20°F).

Variable	Classification	Explanation
e. Salaries of the top five CEO in the United States.	Ratio	The data is numerical, differences are meaningful, and a true zero point exists (zero salary is possible). Ratios are meaningful.
f. Ratings of eight local plays (Poor, Fair, Good, Excellent)	Ordinal	The data is categorical, and the categories have a meaningful order (Excellent is better than Good), but the differences between categories are not measurable or uniform.
g. Times required for mechanics to do a tune-up	Ratio	The data is numerical, differences are meaningful, and a true zero point exists (zero time means the task was instantly completed, or not started/duration is zero). Ratios are meaningful.
h. Ages of students in a classroom.	Ratio	The data is numerical, differences are meaningful, and a true zero point exists (zero age means birth). Ratios are meaningful.
i. Marital status of patients in a physician's office.	Nominal	The data is categorical, and the categories (e.g., single, married, divorced) are simply names or labels. There is no meaningful order or ranking to the categories.
j. Horsepower of tractor engines.	Ratio	The data is numerical, differences are meaningful, and a true zero point exists (0 horsepower means no power). Ratios are meaningful.

Sampling Techniques



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1 Random Samples

Selected by using chance methods or random numbers. Each member of the population has an equal chance of being selected.

Example: Using a lottery method to select 50 students from a university.

Medical example: Randomly selecting 100 patient records from a hospital database to audit treatment outcomes.

2 Systematic Samples

Obtained by numbering each subject of the population and then selecting every k th subject.

Example: Numbering university students from 1 to 1000 and selecting every 10th student (10, 20, 30...).

Medical example: Selecting every 5th patient who enters the clinic on a given day for a satisfaction survey.

3 Stratified Samples

Dividing the population into groups (strata) according to some characteristic, then sampling from each group.

Example: Dividing students into male and female groups, then selecting 100 from each group.

Medical example: Dividing patients by age groups (0-18, 19-40, 41-65, 65+) and sampling from each group to study medication effects.

4 Cluster Samples

The population is divided into groups (clusters), then some clusters are randomly selected and all members of those clusters are used.

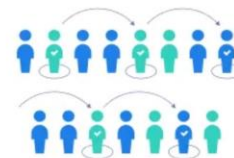
Example: Randomly selecting 5 classrooms from a school and including all students in those classes.

Medical example: Randomly selecting 3 hospital departments and including all patients from those departments in a study.

Simple random sample



Systematic sample



Stratified sample



Cluster sample



Classify each sample as random, systematic, stratified, or cluster:

a) In a large school district, all **teachers** from **two buildings** are interviewed to determine whether they believe the students have less homework to do now than in previous years.

☐ **Cluster**

c) Nursing supervisors are selected using **random numbers** in order to determine annual salaries.

☐ **Random**

d) Every **100th hamburger** manufactured is checked to determine its fat content.

☐ **Systematic**

b) Every **seventh** customer entering a shopping mall is asked to select her or his favorite store.

☐ **Systematic**

e) Mail carriers of a large city are divided into four groups according to **gender (male or female)** and whether they **walk or ride** on their routes. Then **10 are selected from each group** and interviewed to determine whether they have been bitten by a dog in the last year.

☐ **Stratified**

Sampling With vs. Without Replacement



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Sampling With Replacement

After each unit is selected, it is returned to the population and can be selected again in subsequent draws.

Example:

From population {A, B, C, D}, sampling two elements:

First draw: B is selected and returned

Second draw: B could be selected again

Possible samples include: AB, BB, CD, etc.

Medical Example:

Blood samples from a blood bank where the same donor's blood could be selected multiple times.

Sampling Without Replacement

Once a unit is selected, it is removed from the population and cannot be selected again.

Example:

From population {A, B, C, D}, sampling two elements:

First draw: B is selected and removed

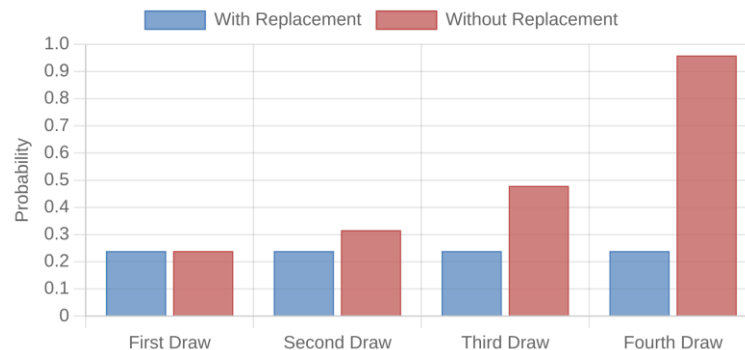
Second draw: Only A, C, D remain available

Possible samples include: BA, BC, BD, etc.

Medical Example:

Selecting patients from a hospital ward for interviews where each patient is interviewed only

Probability of Selection (Population of 4)



The probability of selection changes in sampling without replacement, while it remains constant with replacement.

Research Studies & Experiments



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Research Study

A scientific study of a phenomenon of interest that involves designing sampling protocols, collecting and analyzing data, and providing valid conclusions based on the results of the analyses.

Experiment

A special type of research study in which observations are made after specific manipulations of conditions have been carried out. Experiments provide the foundation for scientific research.

Important Terminology

Treatment Group: Randomly assigned subjects directly exposed to a treatment.

Control Group: Randomly assigned subjects not exposed to a treatment (may receive placebo).

Accuracy/Validity: The correctness of a measurement.

Precision/Reliability: The consistency of a measurement.

Research Study Example

Researchers want to study the influence of drinking tea on sleeping habits. They take a random sample of adults and ask them about their daily tea consumption and sleeping patterns.

Key characteristics:

- Observes existing behaviors
- No manipulation of variables
- Establishes correlations, not causation

Experiment Example

Researchers studying tea's influence on sleep divide participants into three groups: one drinks less tea than usual, one maintains normal consumption, and one drinks more tea. After a period, they measure sleep patterns in all groups.

Key characteristics:

- Deliberate manipulation of variables
- Random assignment to groups
- Control group for comparison
- Can establish causation

Branches of Studies



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Observational Study

الدراسة بالملاحظة

The researcher merely observes what is happening or what has happened in the past and tries to draw conclusions based on these observations.

Example: Observing traffic patterns at an intersection and recording the number of vehicles that pass through.

Traffic Observation Example



Experimental Study

الدراسة بالتجربة

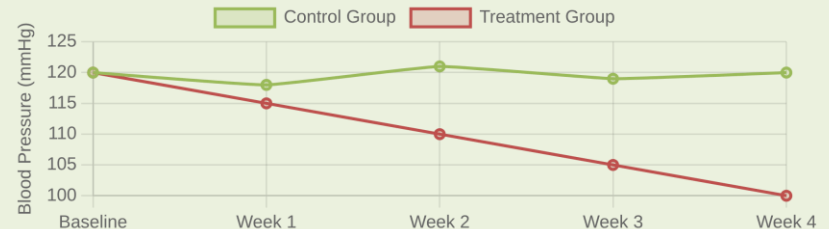
The researcher manipulates one of the variables and tries to determine how the manipulation influences other variables.

Independent Variable: The one being manipulated by the researcher.

Dependent Variable: The resultant variable affected by the manipulation.

Example: Testing how a new medication (independent variable) affects blood pressure (dependent variable).

Blood Pressure Experiment Example



a. Subjects were randomly assigned to two groups, and one group was given an herb and the other group a placebo. After 6 months, the numbers of respiratory tract infections each group were compared.	Experimental	This is an experimental study because the researchers intervened by randomly assigning subjects to different treatment groups (herb vs. placebo) and manipulating the variable (the herb). This allows for a test of cause and effect.
b. A researcher stood at a busy intersection to see if the color of the automobile that a person drives is related to running red lights.	Observational	This is an observational study because the researcher is only watching and recording data (car color and traffic behavior) without influencing or modifying the subjects or their environment. No treatment is imposed.
c. A researcher finds that people who are more hostile have higher total cholesterol levels than those who are less hostile.	Observational	This is an observational study because the researcher is simply noting a relationship or association between two existing characteristics (hostility and cholesterol level). The researcher did not assign hostility levels or impose a treatment to change cholesterol.
d. Subjects are randomly assigned to four groups. Each group is placed on one of four special diets... After 6 months, the blood pressures of the groups are compared to see if diet has any effect on blood pressure.	Experimental	This is an experimental study because the researchers intervened by randomly assigning subjects to different treatment groups (the four special diets) and manipulating the variable (the type of diet). This is a test of the diets' effect on blood pressure.

Question 1

The use of a **Suspect Sample** in statistics is characterized by:

A. Presenting data without proper graphical representation. B. Drawing a conclusion from a sample that is **not representative** of the population. C. Connecting variables that have no direct causal relationship. D. Using overly complex statistical terminology to confuse the audience.

Answer: B. Drawing a conclusion from a sample that is **not representative** of the population.

Question 2

Which misuse is exemplified by the statement: "Our product is 50% more effective!" (but doesn't specify what it's more effective than or at what)?

A. Detached Comparisons B. Implied Connections C. **Changing the Subject** D. Misleading Graphs

Answer: C. **Changing the Subject**

Question 3

A statistical statement like "Our cookies have one-third fewer calories," is an example of a **Detached Comparison** because:

A. It uses numbers that are not whole integers. B. It implies a connection between cookies and health. C. It compares the product to an unknown or unstated reference point. D. It relies on a sample that is too small to be meaningful.

Answer: C. It compares the product to an unknown or unstated reference

Question 4

If an advertisement says, "Eating fish **may** help to reduce your cholesterol," and the word 'may' is used to suggest a connection without proof, this is an example of:

A. Misleading Visuals B. **Implied Connections** C. Detached Comparisons D. Lack of Context

Answer: B. **Implied Connections**

Question 5

A television interviewer only questions 3 people who lived in a movie theater's parking lot and claims it's the "Best movie of the summer." This scenario primarily illustrates which misuse of statistics?

A. Changing the Subject B. Detached Comparisons C. **Suspect Samples** D. Implied Connections

Answer: C. Suspect Samples (The sample of 3 people living on site is clearly not representative of the general population.)

Use and Misuses of Statistics

Suspect Samples

Samples that are not representative of the population.

Example: A TV station interviews only 5 viewers who loved a movie and claims it's the "best movie of the summer."

Changing the Subject

Using statistics to create a favorable impression, even if the numbers are not directly relevant.

Example: "Our product is 60% more effective!" (But doesn't specify what it's more effective than or at what.)

Detached Statistics

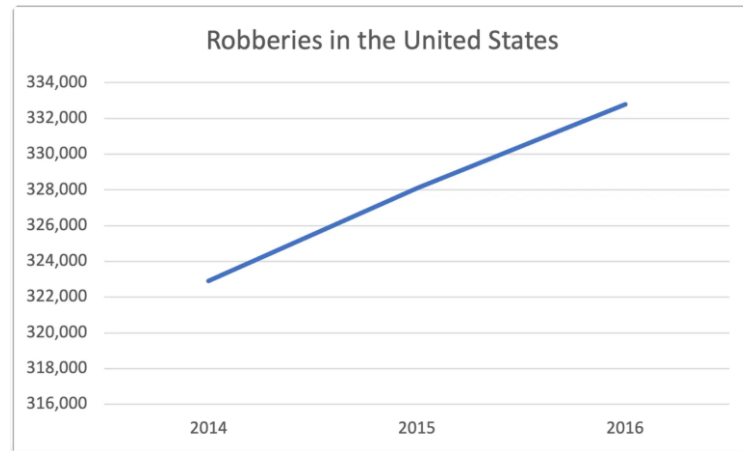
A type of statistic in which no comparison is made.

Example: "Our crackers have one-third fewer calories." (Fewer than what?)

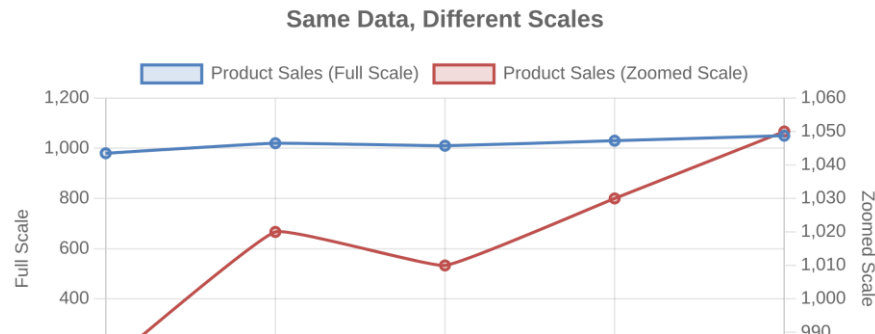
Implied Connections

Implying a connection between variables that may not exist.

Example: "Eating fish may help to reduce your cholesterol." (The word "may" is used



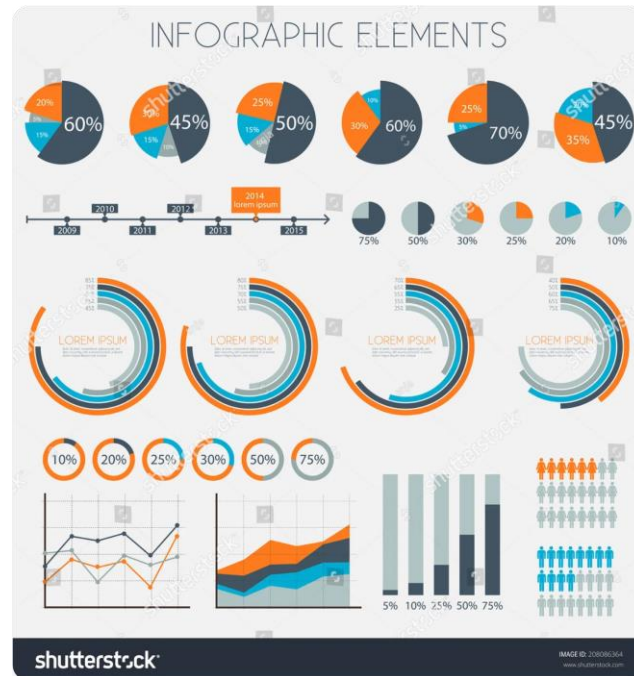
Example of a misleading graph: Same data presented with different Y-axis scales can dramatically change the visual impression of the trend.



Summary & Key Takeaways

Chapter 1: The Nature of Probability & Statistics

- ✓ Statistics is the science of collecting, organizing, analyzing, and drawing conclusions from data
- ✓ Two main types: Descriptive (past/present) and Inferential (future predictions)
- ✓ Variables can be qualitative (categorical) or quantitative (numerical)
- ✓ Four levels of measurement: Nominal, Ordinal, Interval, and Ratio
- ✓ Proper sampling techniques ensure representative data: Random, Systematic, Stratified, and Cluster
- ✓ Studies can be observational (no manipulation) or experimental (with manipulation)
- ✓ Be aware of statistical misuses: suspect samples, changing the subject, detached statistics, and implied connections



Thank you!



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To get
Full course



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