

Fundamentals of Biostatistics (Lectures 1-4)

BIOSTAT 201A Fall 2025

Discussion 2 – October X, 2025

Cindy J. Pang

Outline

1. Lecture 1: Biostatistics, Inference, and Data
 1. Population vs. Sample, Parameter vs. Statistic
 2. Types of Data
2. Lecture 2 : Parameters vs. Statistics, Summary Statistics, and Data Visualization (See Problem 1)
 1. Measures of Location
 2. Measures of Spread
 3. Describing a Distribution
 4. Data Visualization - Boxplots
3. Lecture 3: Probability, Conditioning, and Independence (see Problems 2 and 3)
4. Lecture 4: Random Variables, Sampling, and The Central Limit Theorem
 1. Discrete Random Variables
 2. Properties of the Normal Distribution
 3. Central Limit Theorem

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1.1 Population vs. Sample, Parameter vs. Statistic



1.2 Types of Data

(1) **Quantitative (“Quantifiable”)** – discrete or continuous response of measurable magnitude

- Continuous – can take on an uncountable set of values
- Discrete – can take on a limited, and often fixed number of possible values

(2) **Qualitative** – no corresponding set of numbers

Can you produce some examples of each type of data?

1.2 Types of Data

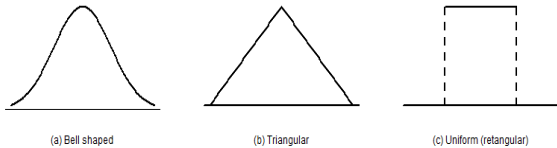
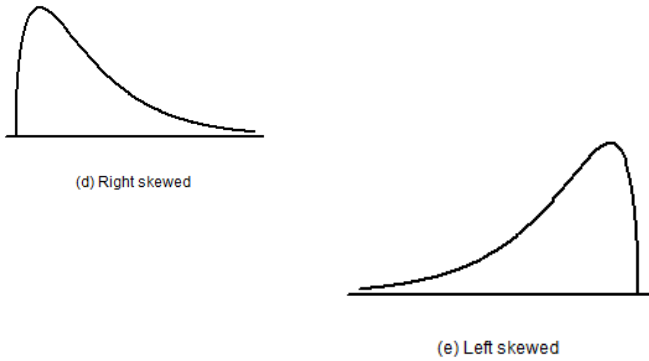
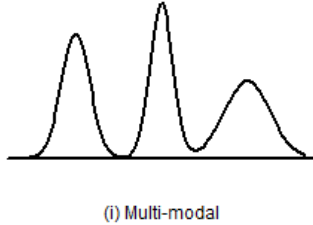
- Stevens' Scale of Data Classification

	Categorical	Order	Equal Spacing	True Zero	Examples
Nominal – categorical data without any sensible ordering of values	X				
Ordinal – categorical or discrete data with a natural ranking/ordering relationship	X	X			
Interval – has a notion of distance, defined by measurement units of equal size	X	X	X		
Ratio – has a notion of magnitudes or “x times greater”	X	X	X	X	

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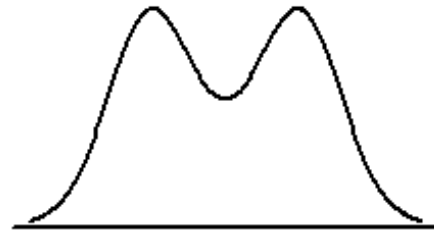
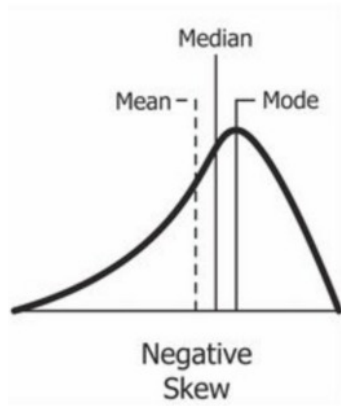
2.1 Measures of Location

	Formula/How to Calculate it	What the Data Looks Like
Mean	$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i$	 (a) Bell shaped (b) Triangular (c) Uniform (rectangular)
Median	Let observations $x_1, \dots, x_n$ be ordered such that $x_1 \leq x_2 \leq \dots \leq x_n$ where x_1 is the minimum and x_n is the maximum If n is even, the median is the average of $x_{\frac{n}{2}}$ and $x_{\frac{n+1}{2}}$ If n is odd, the median is $x_{\frac{n+1}{2}}$	 (d) Right skewed (e) Left skewed
Mode	Most common value	 (i) Multi-modal

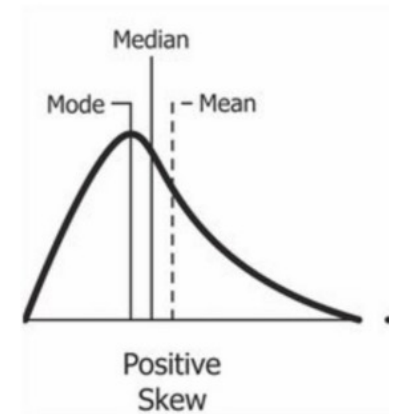
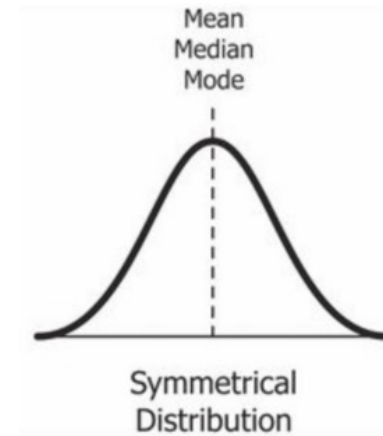
2.2 Measures of Spread

	Formula/How to Calculate it
Range	$\text{Range} = x_{\max} - x_{\min}$
Interquartile Range (IQR)	$\text{IQR} = x_{75\text{th percentile}} - x_{25\text{th percentile}} = Q3 - Q1$
Sample Variance/Standard deviation ($\sqrt{s^2}$)	$s^2 = \frac{\sum_{i=1}^n (x_i - \bar{x})^2}{n - 1}$

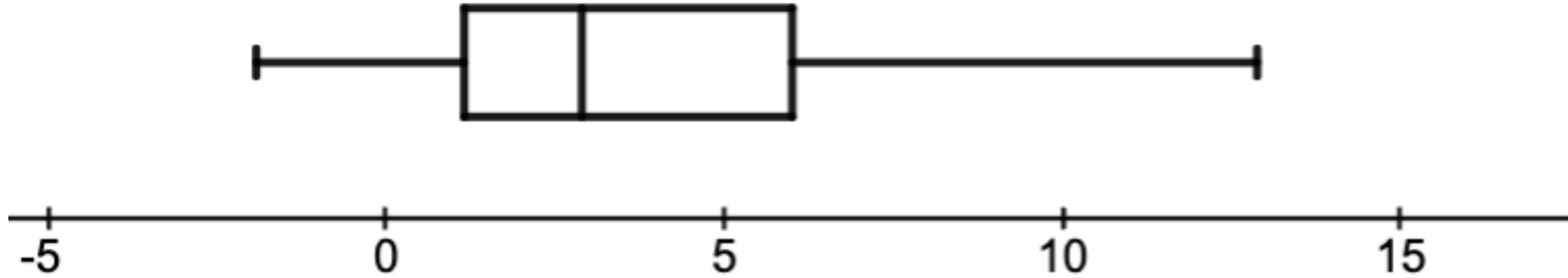
2.3 Describing a Distribution



(h) Bimodal



2.4 Data Visualization - Boxplots



2.4 Data Visualization – Stem and Leaf

15, 16, 21, 23, 23, 31, 35, 39, 40, 41, 46, 55, 56

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Some general probability rules

- Complements: $P(\bar{E}) = 1 - P(E)$
- Independence of Events:
 - (1) Event A is independent of Event B if the joint probability of A and B can be expressed as:

$$P(A \cap B) = P(A)P(B)$$

- (2) Event A is independent of Event B if the following conditional holds:

$$P(A|B) = P(A), \quad P(B) > 0$$

- Conditional Probability: $P(A|B) = \frac{P(A \cap B)}{P(B)} = \frac{P(A|B)P(B)}{P(B)}$
- Rule of Total Probability: $P(A) = P(A|B)P(B) + P(A|\bar{B})P(B)$

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4.1 Discrete Random Variables - Example

Probability Mass Function (PMF) – probability distribution for a discrete variable

Value	1	2	4	6
Probability	0.2	0.1	0.4	0.3

Exercise. Compute

(a) Expected Value of X:

(b) Variance of X:

(c) Construct the cumulative distribution function (cdf)

Expected Value of a Discrete RV:

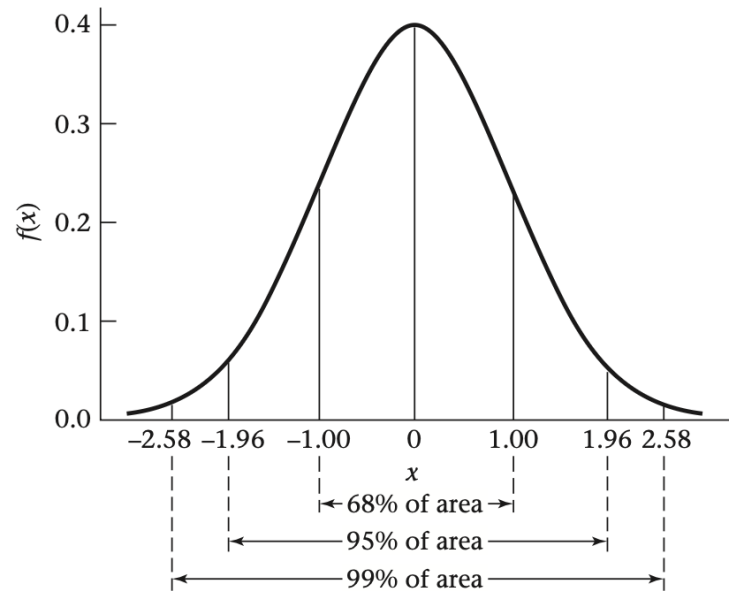
$$\mathbb{E}(X) = \sum_{i=1}^n x_i \Pr(X = x_i)$$

Variance of a Discrete RV:

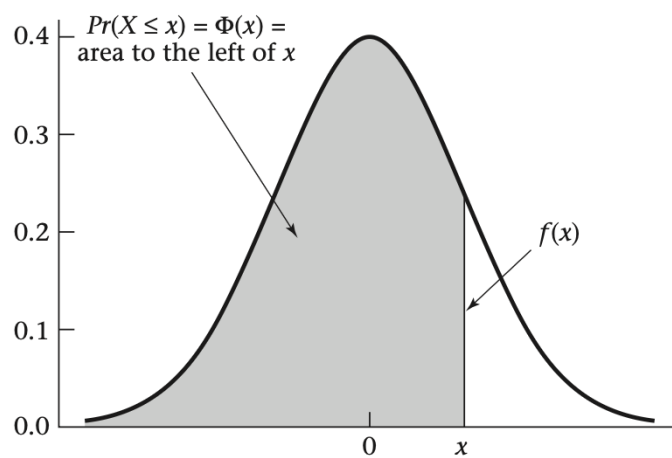
$$\text{Var}(X) = \mathbb{E}(X - \mu)^2 = \sum_{i=1}^n x_i^2 \Pr(X = x_i) - \mu^2$$

4.2 Properties of the Normal Distribution – The Empirical Rule and CDF

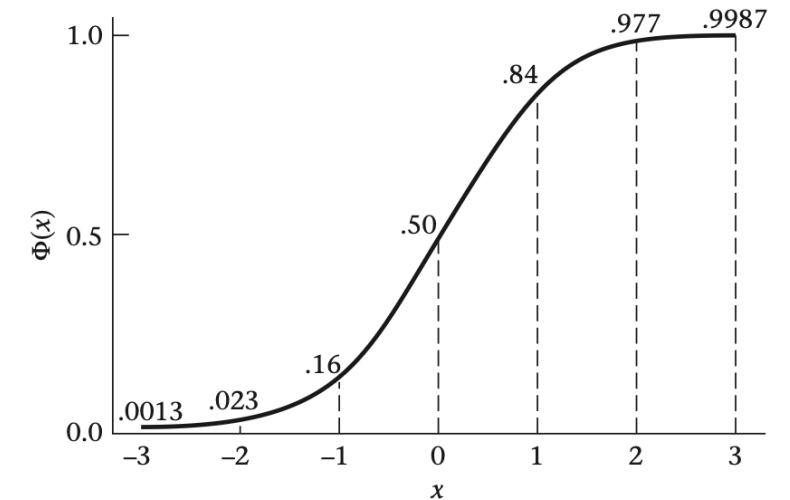
Empirical properties of the standard normal distribution



The cdf $[\Phi(x)]$ for a standard normal distribution



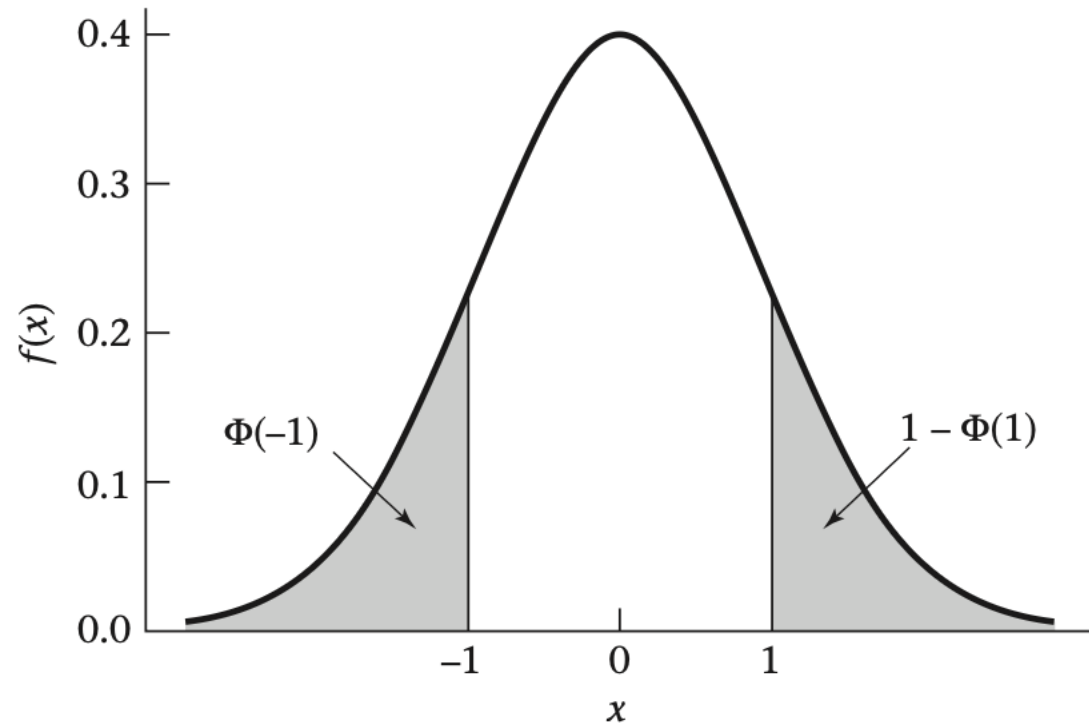
The cdf for a standard normal distribution $[\Phi(x)]$



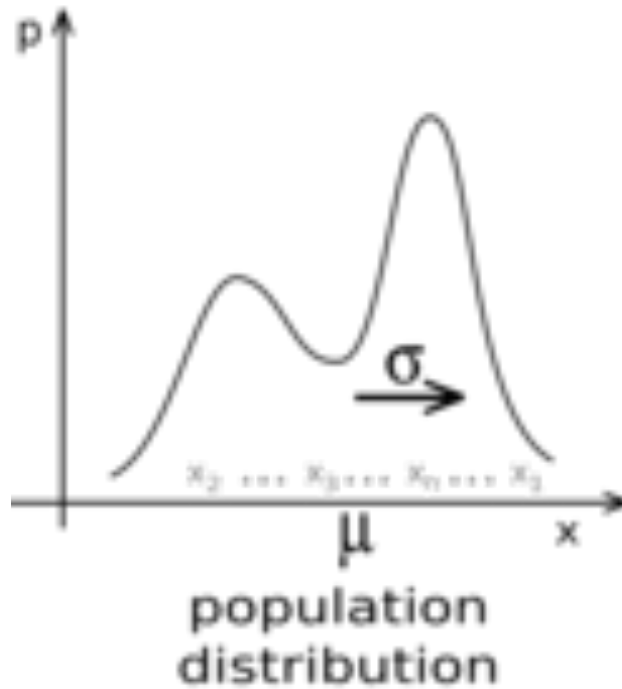
4.2 Properties of the Normal Distribution - Symmetry

$$\Phi(-x) = 1 - \Pr(X \leq x) = 1 - \Phi(x)$$

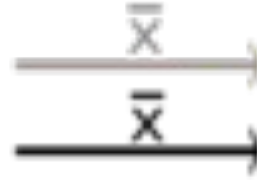
Illustration of the symmetry properties of the normal distribution



4.3 Central Limit Theorem



samples
of size n



A diagram showing two horizontal arrows. The top arrow is labeled $\bar{x}$ and the bottom arrow is labeled $\bar{x}$.

