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Mathematics and Biostatistics **First Stage**

LECTURE 7
Probability concepts

BY

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OUTLINE

- **Probability concepts :**
- Properties of probability
- Set theory and set notation (basic notation)
- counting techniques- permutations and combinations
- calculating the probability of an events
- probability distribution of discrete variable
- binomial distribution, Poisson distribution
- continues probability distribution and normal distribution, review questions and exercises

PROBABILITY CONCEPTS IN BIOSTATISTICS

- Probability is a fundamental concept in biostatistics, providing the foundation for statistical inference and decision-making in medical and biological research. Understanding probability allows researchers to quantify uncertainty, make predictions, and draw conclusions from data.

1. PROPERTIES OF PROBABILITY

- Probability is a measure of the likelihood that an event will occur. It is quantified as a number between 0 and 1, where:

- **0** indicates impossibility (the event will not occur).
- **1** indicates certainty (the event will occur).

- **Key Properties:**

1. **Non-negativity**: For any event A, $P(A) \geq 0$
2. **Additivity**: If two events AA and BB are mutually exclusive (cannot occur simultaneously), then $P(A \cup B) = P(A) + P(B)$.
3. **Normalization**: The probability of the entire sample space S is 1, i.e., $P(S) = 1$.

2.SET THEORY AND SET NOTATION

- Set theory is used to describe collections of outcomes or events. Basic notation includes:
- **Sample Space (S)**: The set of all possible outcomes.
- **Event (A)**: A subset of the sample space.
- **Union ($A \cup B$)**: The event that either A or B occurs.
- **Intersection ($A \cap B$)**: The event that both A and B occur.
- **Complement (A^c) :** The event that A does not occur.

3. COUNTING TECHNIQUES: PERMUTATIONS AND COMBINATIONS

- Counting techniques are used to determine the number of ways events can occur.
- **Permutations:**
- The number of ways to arrange r objects from a set of n objects, where order matters:

$$P(n, r) = \frac{n!}{(n-r)!}$$

- **Combinations:**
- The number of ways to choose r objects from a set of n objects, where order does not matter:

$$C(n, r) = \frac{n!}{r!(n-r)!}$$

CALCULATING THE PROBABILITY OF AN EVENT

- The probability of an event A is calculated as:

$$P(A) = \frac{\text{Number of favorable outcomes}}{\text{Total number of outcomes}}$$

- **Example in Biostatistics:**

- In a study of 100 patients, 20 have a specific gene mutation. The probability of randomly selecting a patient with the mutation is:

$$P(A) = \frac{20}{100} = 0.20$$

5. PROBABILITY DISTRIBUTION OF A DISCRETE VARIABLE

- A probability distribution describes the probabilities of all possible outcomes for a discrete random variable.
- **Example in Biostatistics:**
- Let X be the number of defective genes in a patient. Suppose:
- $P(X=0)=0.5$, $P(X=1)=0.3$, $P(X=2)=0.2$

This defines the probability distribution of X.

6. BINOMIAL DISTRIBUTION

- The binomial distribution models the number of successes in n independent trials, each with probability p of success.
- **Formula:**
- $P(X=k)=C(n,k)\cdot p^k\cdot(1-p)^{n-k}$

Example in Biostatistics:

- In a clinical trial, the probability of a patient responding to a treatment is p=0.6. If 5 patients are treated, the probability that exactly 3 respond is:
- $P(X=3)=C(5,3)\cdot 0.6^3\cdot 0.4^2=0.3456$

7. POISSON DISTRIBUTION

- The Poisson distribution models the number of rare events occurring in a fixed interval of time or space.
- **Formula:**

$$P(X = k) = \frac{\lambda^k e^{-\lambda}}{k!}$$

- where λ is the average rate of occurrence.

Example in Biostatistics:

- Suppose the average number of hospital admissions per day for a rare disease is 2. The probability of exactly 3 admissions in a day is:

$$P(X = 3) = \frac{2^3 e^{-2}}{3!} = 0.1804$$

8. CONTINUOUS PROBABILITY DISTRIBUTION AND NORMAL DISTRIBUTION

- Continuous distributions describe variables that can take any value within an interval. The **normal distribution** is the most important continuous distribution in biostatistics.
- **Normal Distribution:**
- Symmetric, bell-shaped curve.
- Defined by mean (μ) and standard deviation (σ).
- Probability density function:

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$$

Example in Biostatistics:

- Suppose the blood pressure of adults follows a normal distribution with $\mu=120$ mmHg and $\sigma=10$ mmHg. The probability that a randomly selected adult has a blood pressure between 110 and 130 mmHg can be calculated using the standard normal table.

9. REVIEW QUESTIONS AND EXERCISES

- **Example:**
- In a study of 100 patients, 30 have hypertension, and 20 have diabetes. If 10 patients have both conditions, what is the probability that a randomly selected patient has hypertension given that they have diabetes?
- **Solution**:
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$$P(\text{Hypertension}|\text{Diabetes}) = \frac{P(\text{Hypertension} \cap \text{Diabetes})}{P(\text{Diabetes})} = \frac{10/100}{20/100} = 0.5$$

- **Example:**
- In a study, you need to select a committee of 3 members from a group of 10 researchers. How many different committees can be formed?

- **Solution**:

$$C(10,3) = \frac{10!}{3!7!} = 120$$

- **Example:**
- In a population of 1,000 individuals, 150 have a specific genetic mutation. What is the probability that a randomly selected individual has the mutation?
- **Solution**:

$$P(\text{Mutation}) = \frac{150}{1000} = 0.15$$

- Thanks for lessening ..

Any questions?