Causal Inference Notes- IUIU MPH 2024

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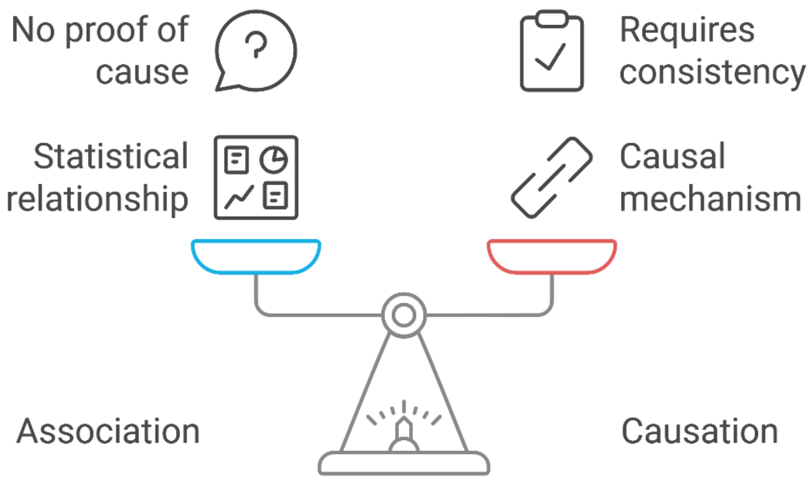
1. The Difference Between Association and Causation

- ✓ Association implies a statistical relationship between two variables but does not establish that one variable causes change in another.
- ✓ Causation indicates that changes in one variable (cause) produce changes in another variable (effect). Causation requires a mechanism that logically links the cause and effect, supported by consistent evidence across multiple studies.

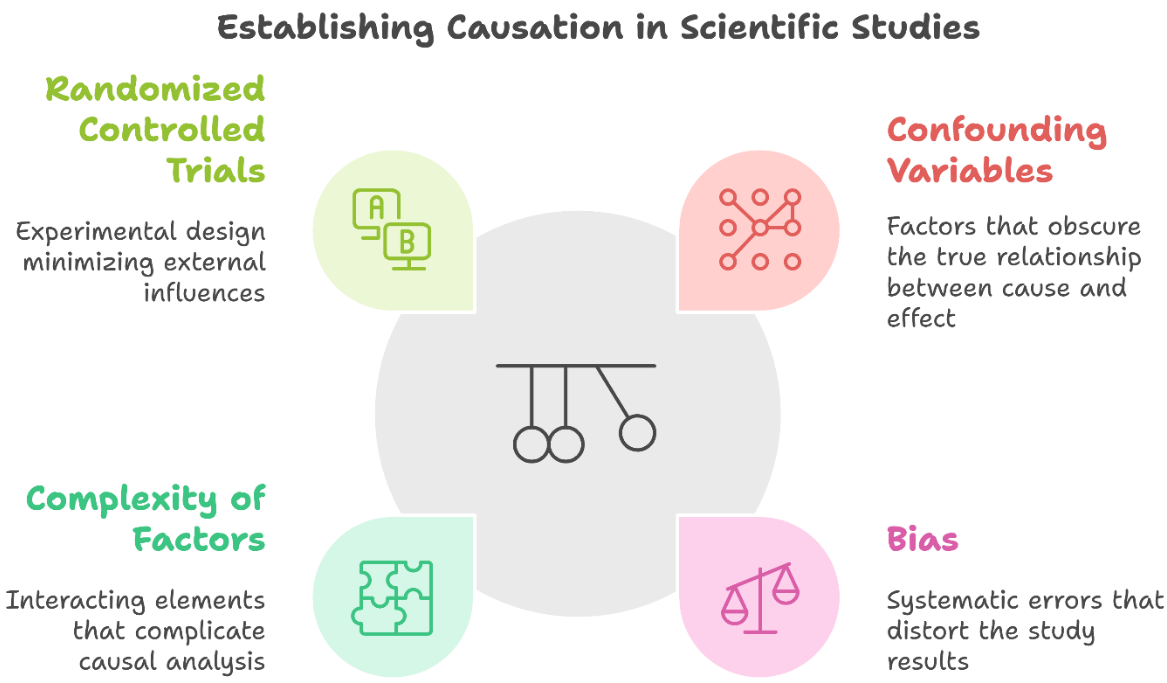
For example, smoking is associated with lung cancer, but to say smoking causes lung cancer, we need more than correlation; we need mechanisms and consistency of effect in various studies.



Understanding the difference between association and causation.

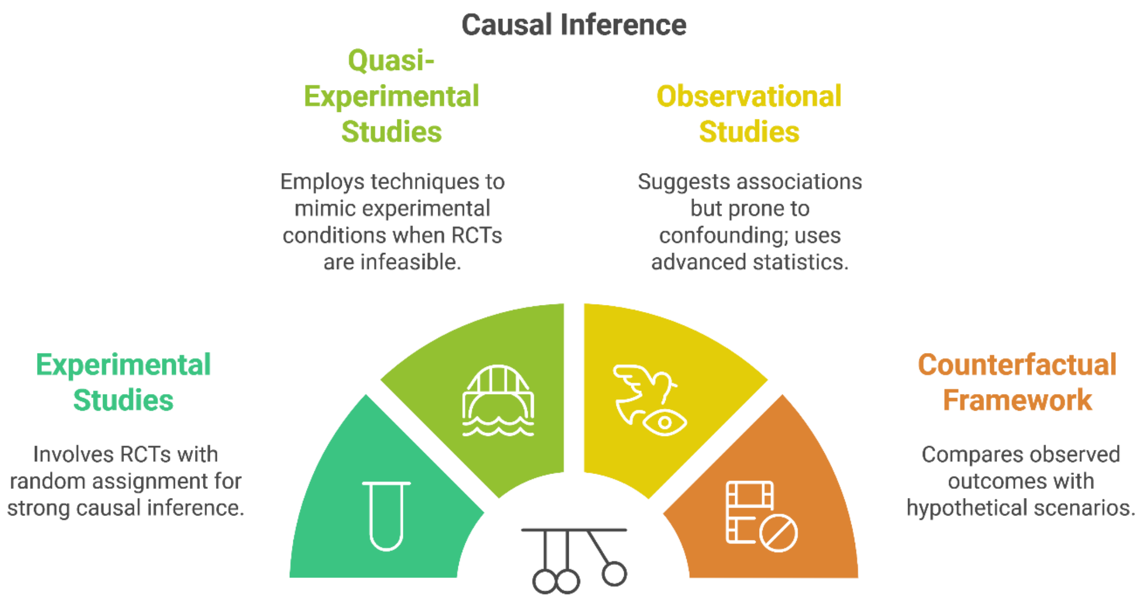
2. The Concept of Causation

- ✓ Causation is the idea that an event or factor directly influences an outcome. Understanding causation helps explain "why" an outcome occurs.
- ✓ In scientific studies, causation is often hard to prove due to confounding variables, bias, and the complexity of multiple interacting factors. Randomized controlled trials (RCTs) are the gold standard for establishing causation because they limit these external influences.



3. Types of Causal Inference

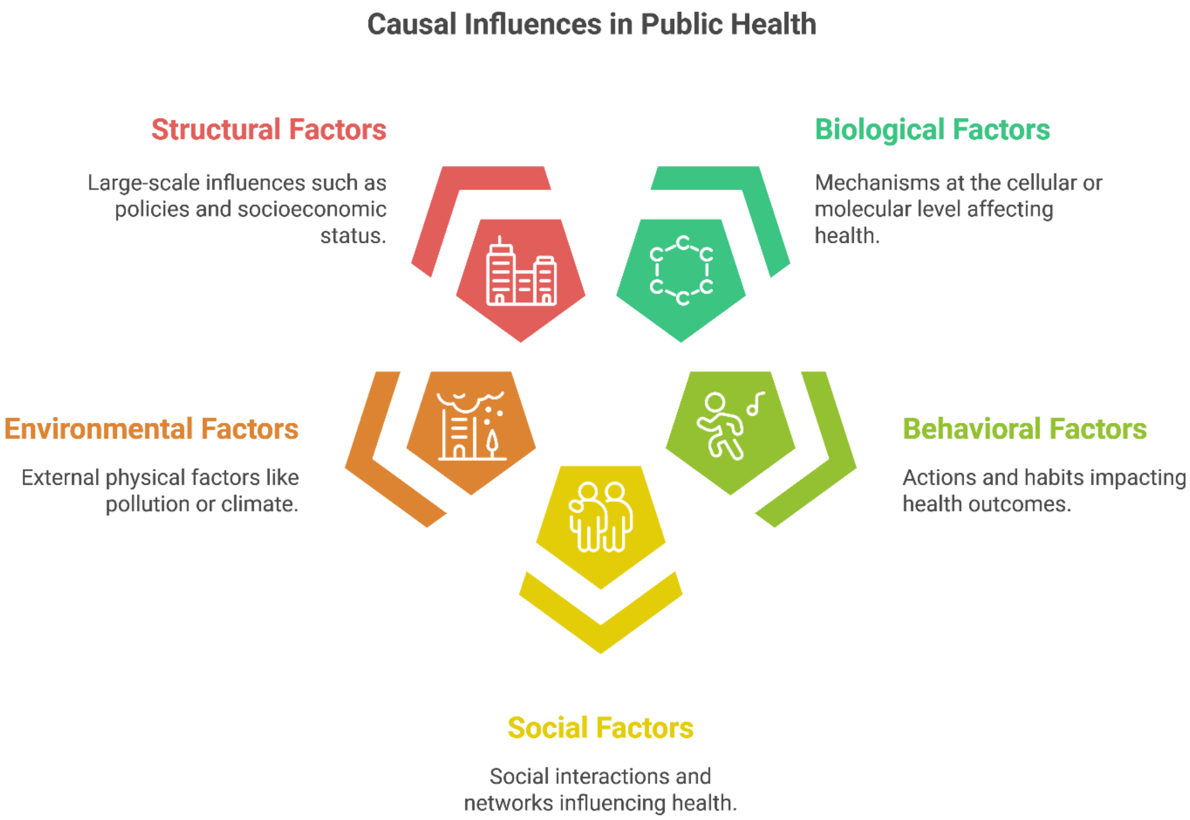
- ✓ Experimental Studies: These include RCTs where participants are randomly assigned to treatment or control groups, allowing strong causal inference due to the controlled setup.
- ✓ Quasi-Experimental Studies: Used when RCTs are not feasible. Techniques like propensity score matching, instrumental variables, and interrupted time series are employed to mimic experimental conditions.
- ✓ Observational Studies: These include cohort, case-control, and cross-sectional studies. While they often suggest associations, they are prone to confounding. Advanced statistical techniques, such as multivariable adjustments, are used to improve causal inference.
- ✓ Counterfactual Framework: Based on comparing observed outcomes with what would have occurred if a different exposure level had been observed in the same population.



4. Different Levels at Which Causes May Be Found

- ✓ Biological: Mechanisms at the cellular or molecular level, e.g., genetic predisposition, immune response.
- ✓ Behavioral: Actions and habits, such as smoking or exercise, that impact health outcomes.
- ✓ Social: Factors involving social interactions and networks, such as family support or peer influence.
- ✓ Environmental: External physical factors like air pollution or climate.
- ✓ Structural: Large-scale influences such as healthcare policies, socioeconomic status, or systemic racism.

Each level represents a different domain of causal influence, and understanding these levels can provide a comprehensive view of causation in complex public health issues.



5. Concept of Causation

Ways of Inferring Causation:

1. Temporal Relationship: The cause must precede the effect in time.

2. Strength of Association: Strong associations (e.g., high relative risk) are more likely to indicate causation.

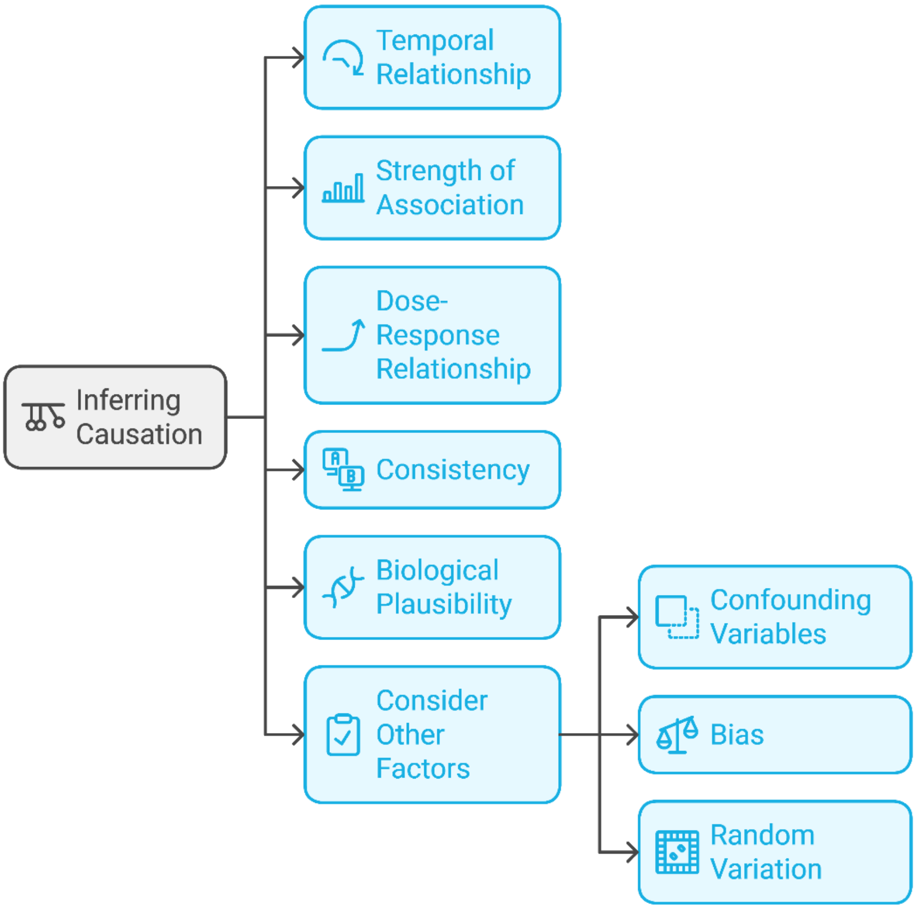
3. Dose-Response Relationship: A gradient in effect with an increase in exposure supports causation.

4. Consistency: Replication of findings in different studies and populations strengthens causal claims.

5. Biological Plausibility: A logical biological mechanism connecting cause and effect supports causation.

Other Considerations Before Inferring Causation:

- ✓ Confounding Variables: Other factors that may influence both the exposure and outcome.
- ✓ Bias: Systematic errors in study design or data collection.
- ✓ Random Variation: Chance findings, especially in small studies, may appear as associations.



6. Establishing Causation

Koch’s Postulates

Developed in the 19th century to identify the causative agent of infectious diseases:

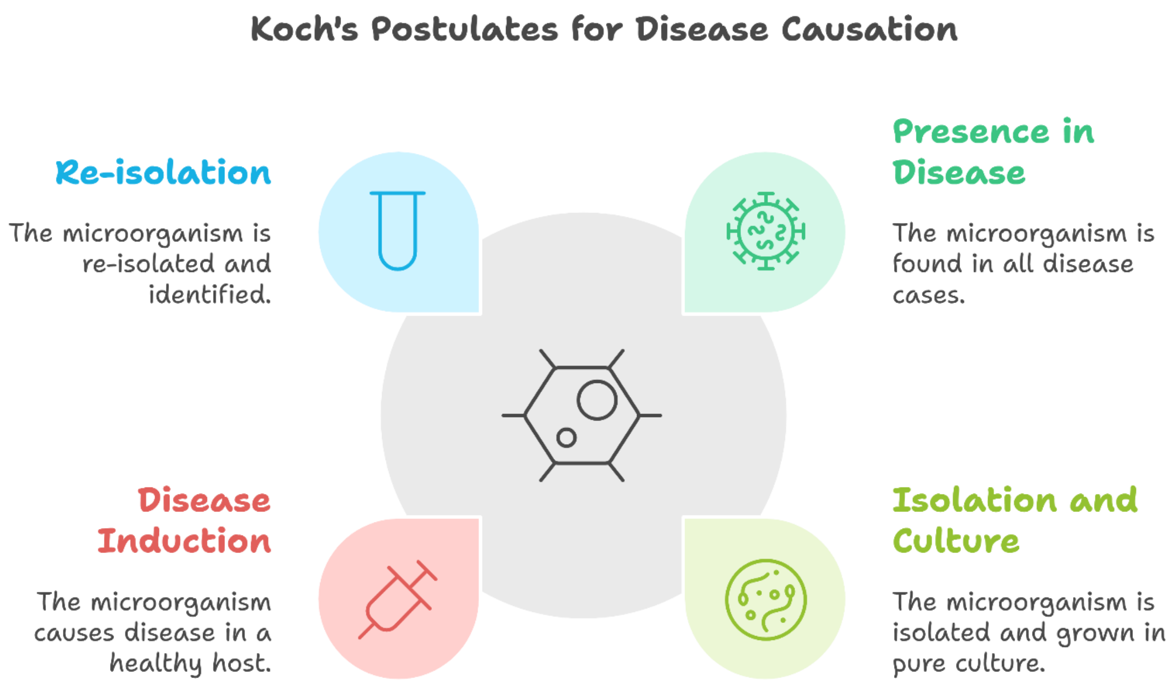
1. The microorganism must be present in every case of the disease.

2. The microorganism must be isolated and grown in pure culture.

3. The cultured microorganism must cause the disease when introduced into a healthy host.

4. The microorganism must be re-isolated from the newly infected host and identified as identical to the original organism.

While useful for infectious diseases, Koch's postulates have limitations with non-infectious diseases and multifactorial conditions.



Evan's Concept of Causation

A set of nine criteria for establishing causation in chronic diseases:

1. Strength of Association: High relative risks suggest causation.

2. Consistency: Observed in various studies and conditions.

3. Specificity: A cause leads to a single effect (though this is often weak).

4. Temporality: Exposure must precede the outcome.

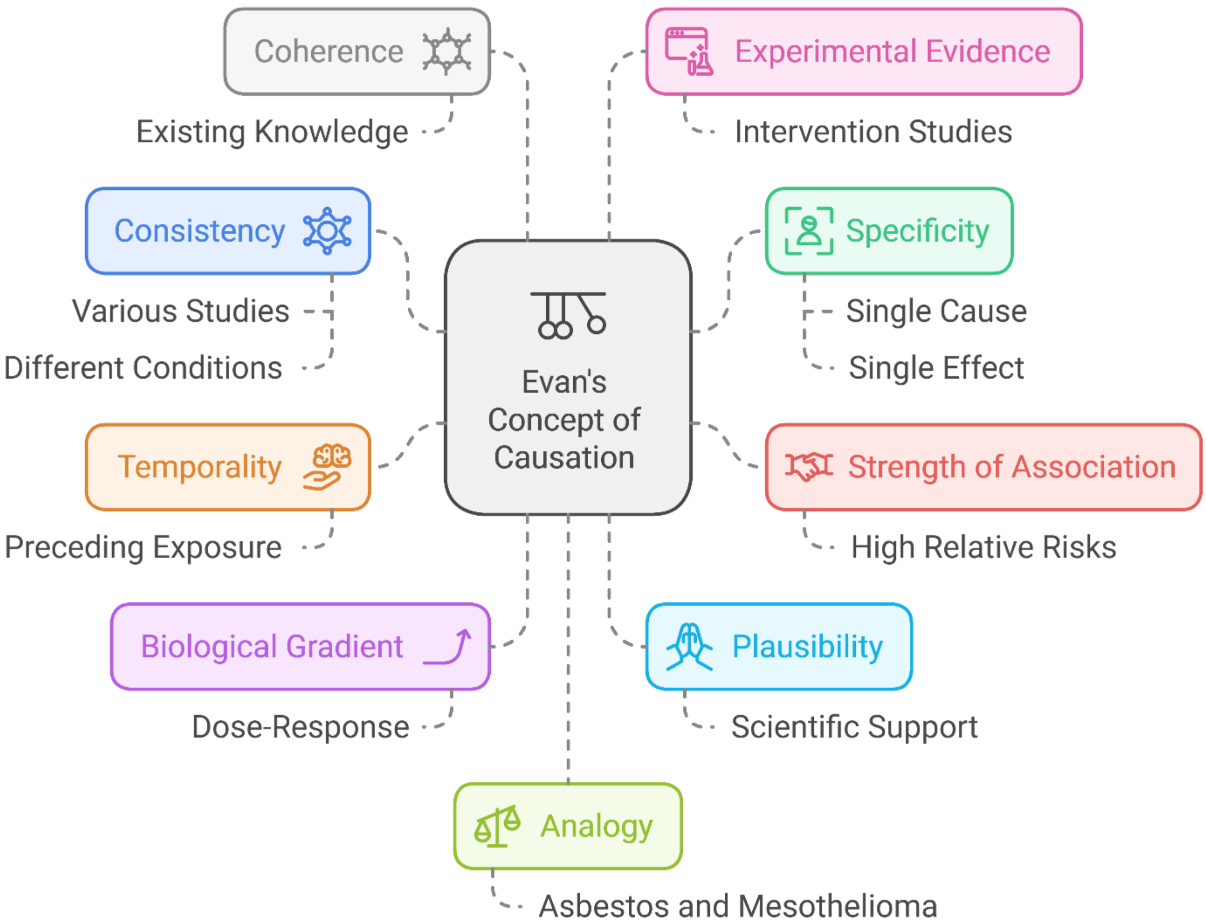
5. Biological Gradient: Dose-response relationship supports causation.

6. Plausibility: Supported by current biological or scientific knowledge.

7. Coherence: Findings do not contradict existing knowledge.

8. Experimental Evidence: Evidence from intervention studies.

9. Analogy: Similar factors cause similar outcomes (e.g., asbestos and mesothelioma).



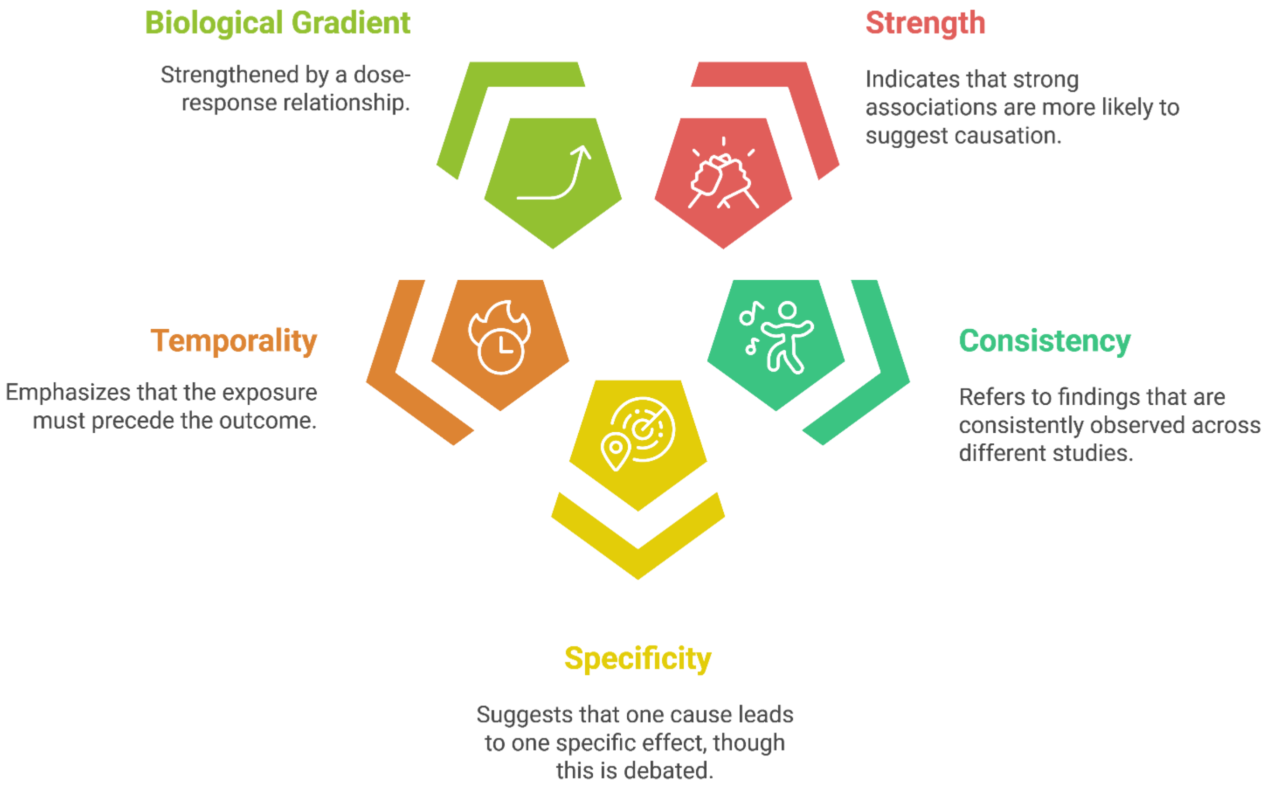
Hill's Criteria for Causation

Sir Austin Bradford Hill proposed criteria in 1965 to help establish causation in epidemiological research:

1. Strength: Strong associations more likely indicate causation.
2. Consistency: Consistent findings across studies strengthen the causal claim.
3. Specificity: One cause leads to one effect, though this is controversial.
4. Temporality: Exposure precedes outcome.
5. Biological Gradient: A dose-response curve strengthens causation.
6. Plausibility: Biological or scientific rationale exists.
7. Coherence: Aligns with current knowledge.
8. Experiment: Causal effect can be demonstrated experimentally.
9. Analogy: Similar situations may imply causation.

Hill's criteria are not strict rules but guidelines to consider causality in observational studies.

Hill's Criteria for Causation



Rothman's Multi-Causality Model

Proposed by epidemiologist Kenneth Rothman, this model emphasizes that multiple factors often contribute to the development of disease:

I. Sufficient Cause: A complete set of causal components that inevitably lead to the disease (e.g., in lung cancer, smoking may be a component of one sufficient cause).
II. Component Cause: An individual factor that contributes to disease but may not be sufficient alone.
III. Necessary Cause: A factor required for the disease to occur (e.g., the presence of a pathogen in infectious diseases).

Rothman's model suggests that multiple pathways can lead to the same outcome, emphasizing the importance of understanding component causes and combinations of risk factors in disease development.