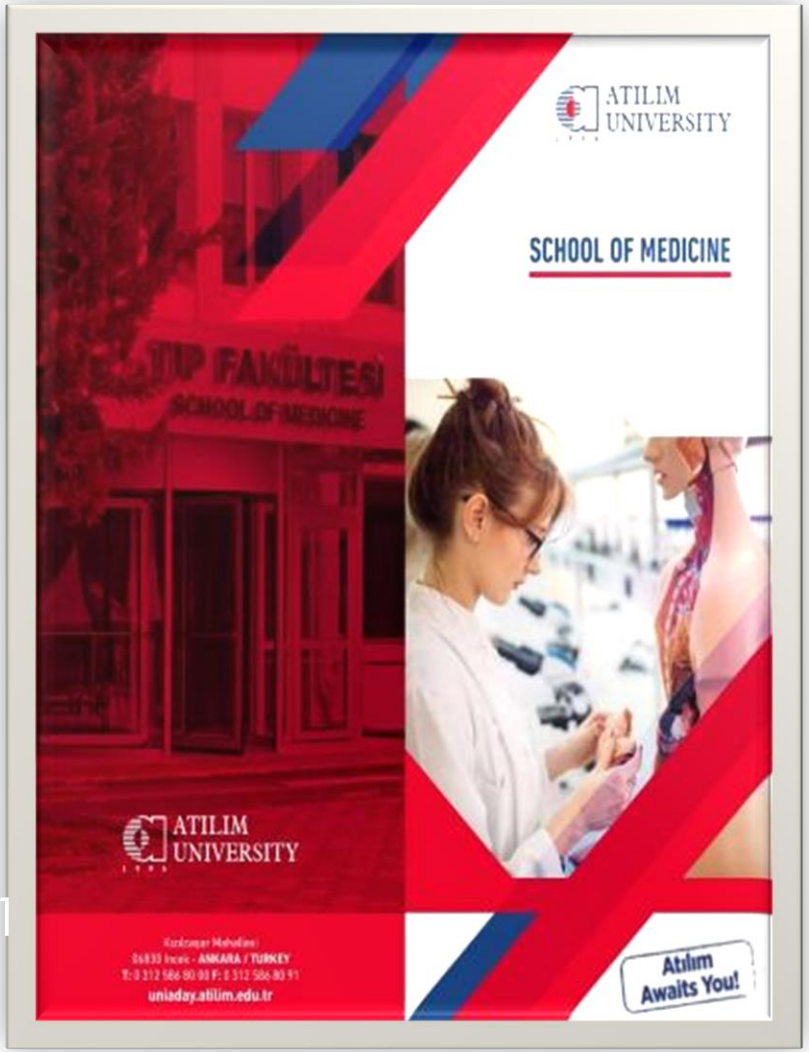

Causality in Medicine:
Meaning and Critical Function

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The relating of causes to the effects they produce. Most of Epidemiology concerns causality and several types of causes can be distinguished. It must be emphasised, however, that Epidemiological evidence by itself is insufficient to establish causality, although it can provide powerful circumstantial evidence.

Phase 1 lecture, 2024 - 2025 academic year, Fall semester

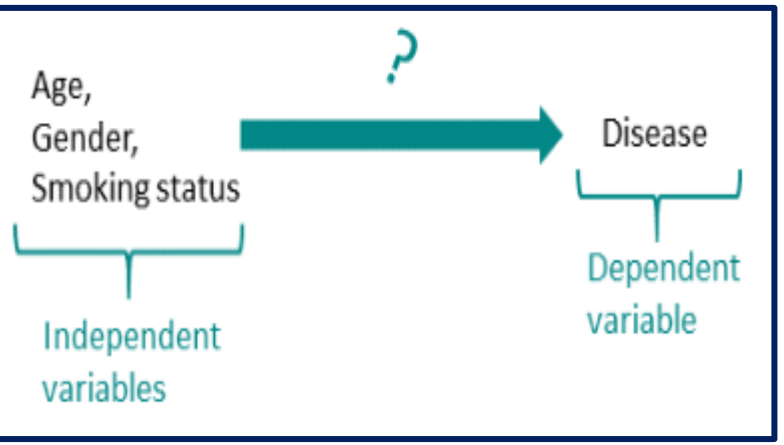
30th Sept. 2024, Ankara - TURKIYE

Causal connection of the Events

Learning Objectives

After this course, you will be able to :

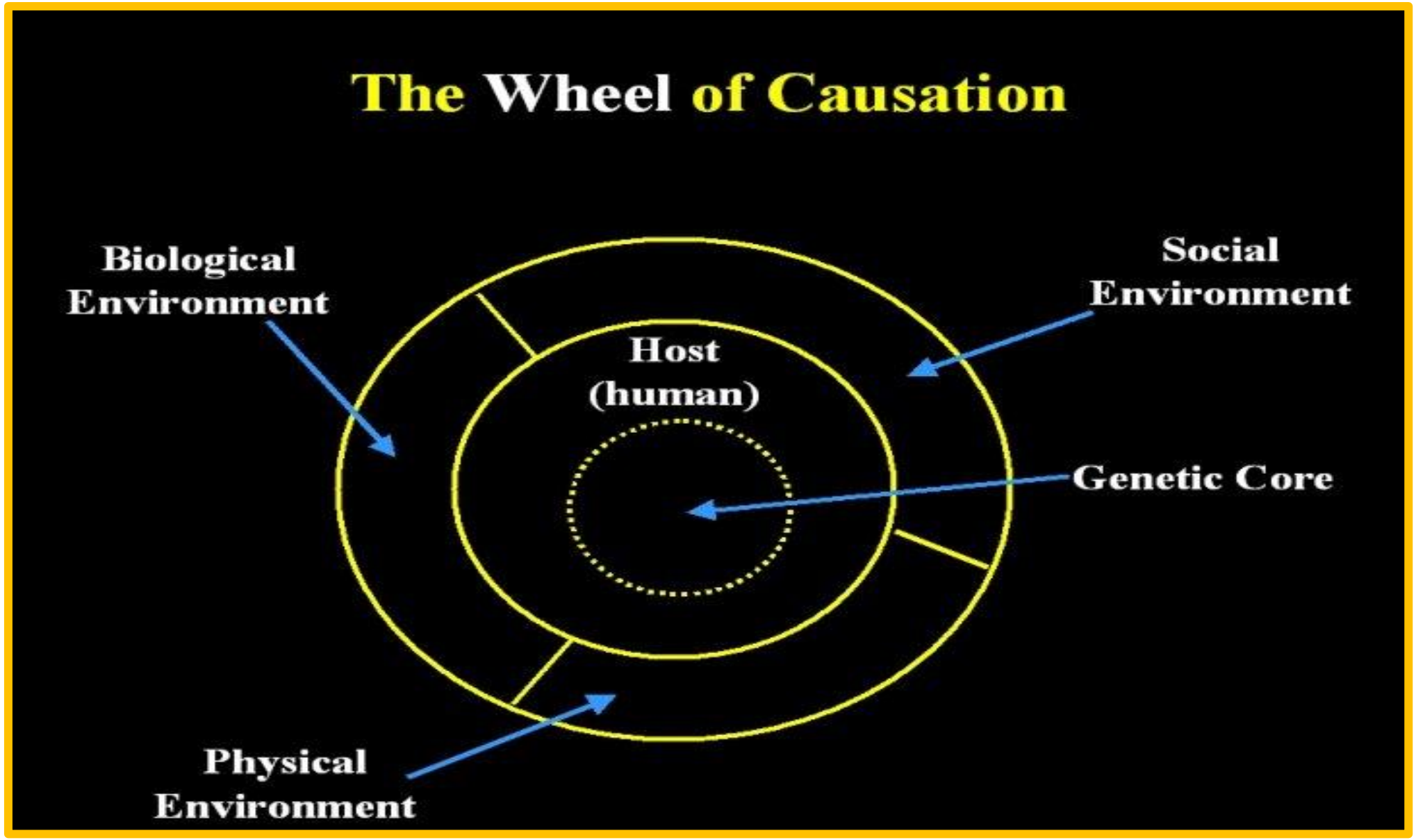
- **describe** the meaning of «*association*» and its types
- *define Causal and Non-Causal types of association*
- **identify** confounding factors and how to eliminate
- *recognize the core functions of causal association and infe**rence***
- **describe** the differences between associaton and correlation
- ***list B. Hill's criteria for Causal Relationship / Association***
- **realize** how functions Causality and Causal / Primary relationship in Epidemiology & Public Health



Presentation outline

- Introduction
- Approaches for studying disease etiology
- Type of Association
- Causal relationship
- Type of causal relationship
- Guidelines to asses causality
- Causal inference and conclusion
- Reference

Causality & Environment



https://doi.org/10.1016/j.crvi.2019.03.001

What is Association?

- *Statistical dependence between 2 or more events, characteristics, or other variables.*
- An **association** may be fortuitous *(by chance)* or may be produced by various other circumstances; the presence of an association does not necessarily imply a ***causal relationship***.

Causality is the science of *«Cause & Effect»*

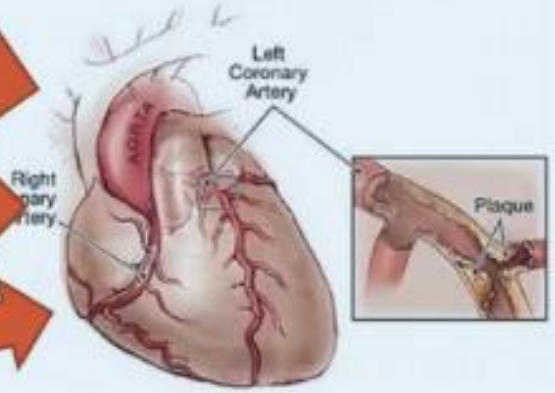
International Epidemiological Association

One to one causal association-

Measles virus

Measles

Multifactorial association-



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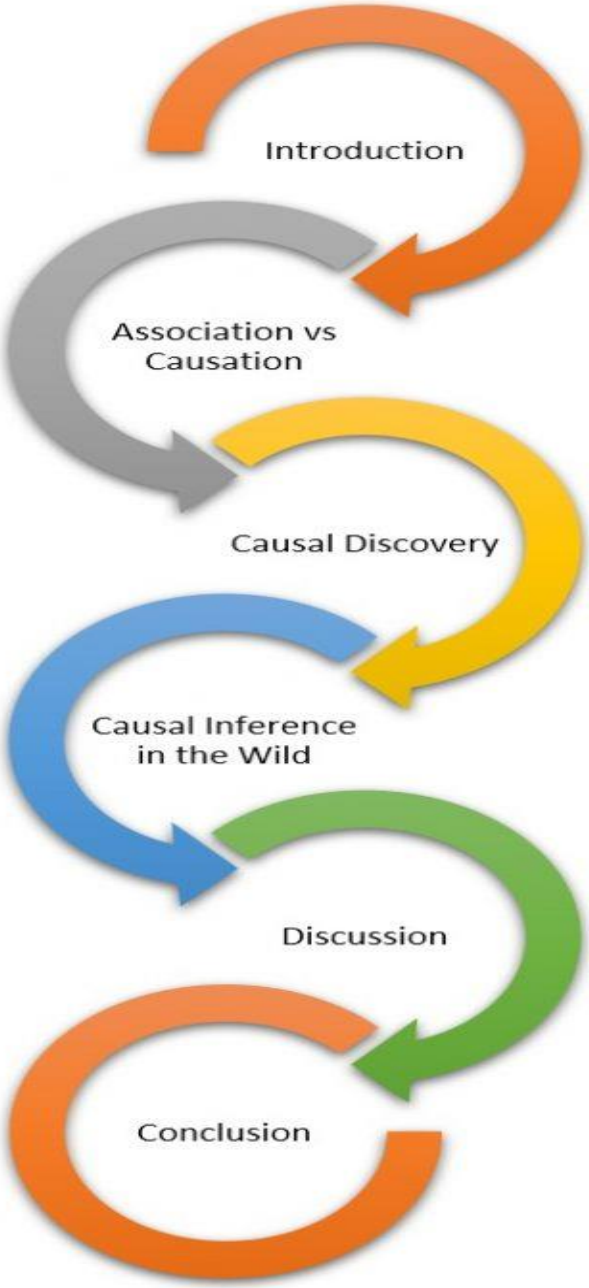
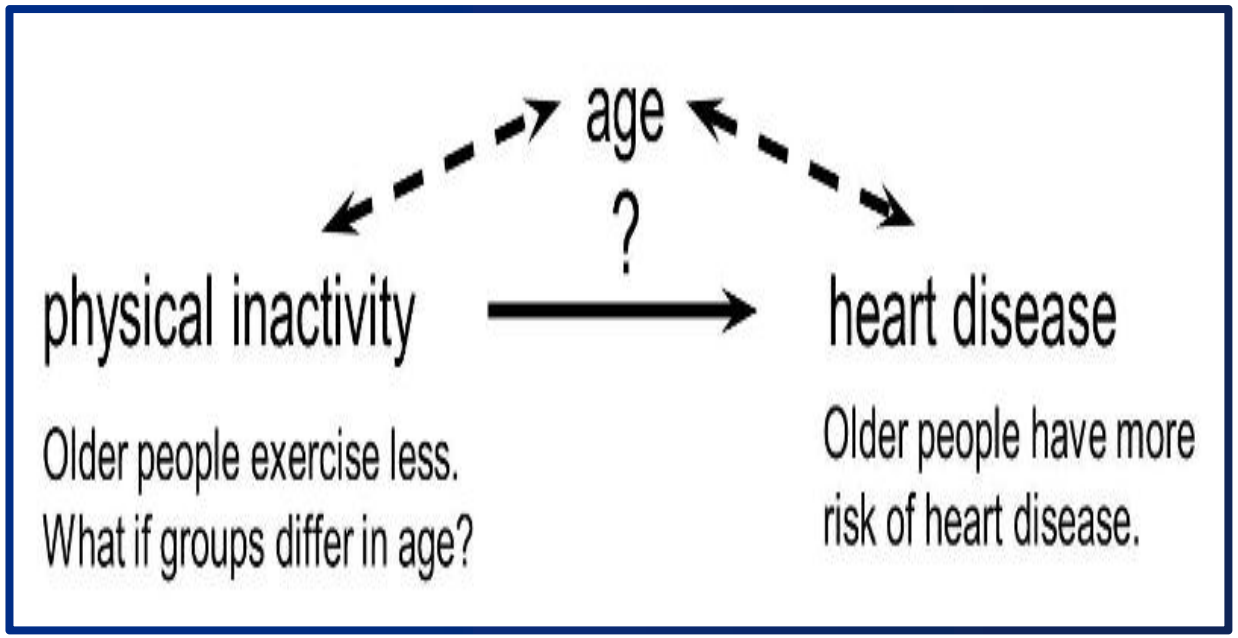
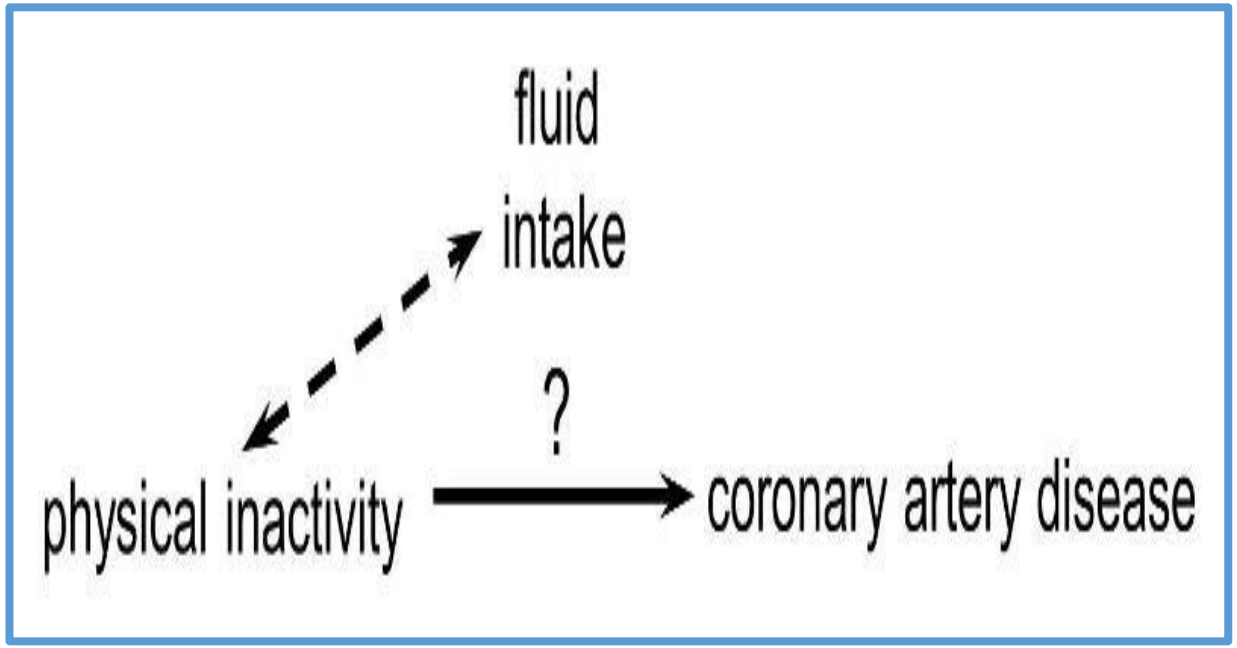


What is Confounding?

- ***Confounding variable, confounder***
  A variable that can cause or prevent the outcome of interest, is not an intermediate variable, and is ***associated*** with the factor under investigation.
- A **confounding variable** may be due to chance or bias. Unless it is possible to adjust for confounding variables, their effects cannot be distinguished from those of factor(s) being studied.



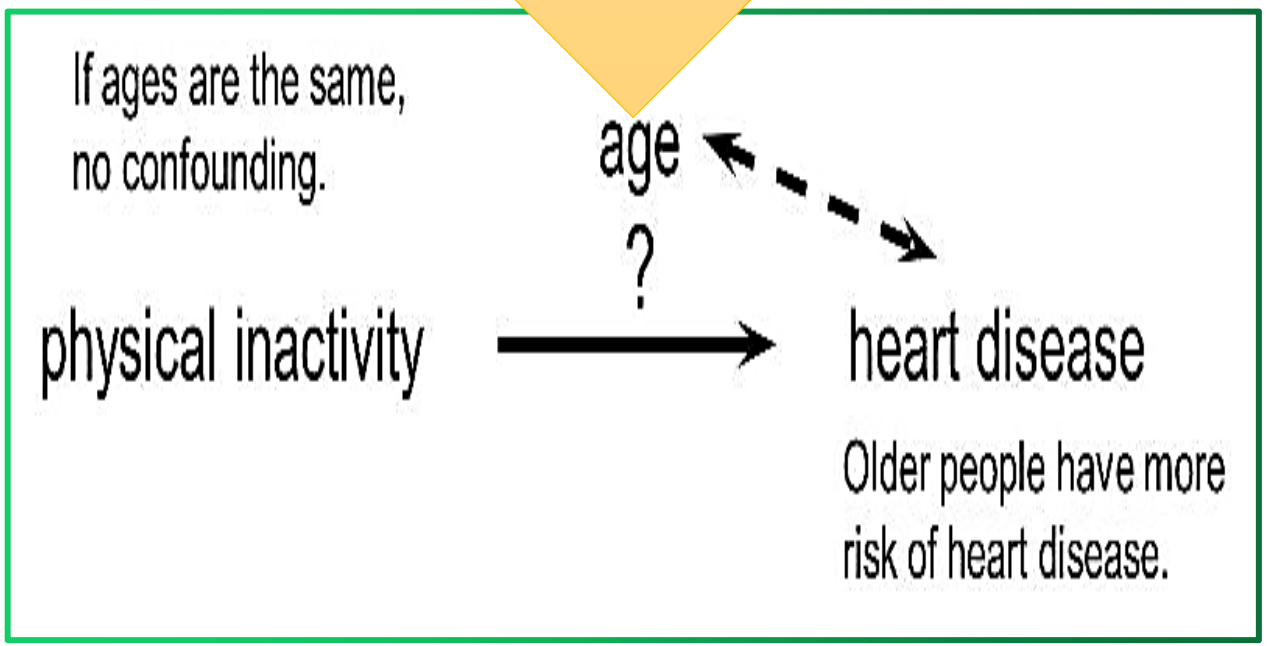


https://sphweb.bumc.bu.edu/otlt/mph-modules/bs/bs704-ep713_confounding-em/BS704-EP713_Confounding-EM2.html

What is Confounding?

- **Confounding** is a distortion *(inaccuracy)* in the estimated measure of association that occurs when the primary exposure of interest is mixed up with some other factor that is associated with the outcome.
- *In the diagram right the primary goal is to ascertain the strength of association between physical inactivity and heart disease.*
- Age is a **confounding factor** because it is associated with the exposure *(meaning that older people are more likely to be inactive)*, and it is also associated with the outcome *(because older people are at greater risk of developing heart disease)*.

Most health problems have «many» determinants (risk factors), so it is not surprising that there is a lot of potential for confounding. While this can represent a barrier to testing a particular hypothesis, it is also an opportunity to dissect the many determinants and to define their relative importance.



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What is Confounding?

Confounding variable

Hot temperatures

Rate of ice cream consumption

Number of sunburns

Scribbr

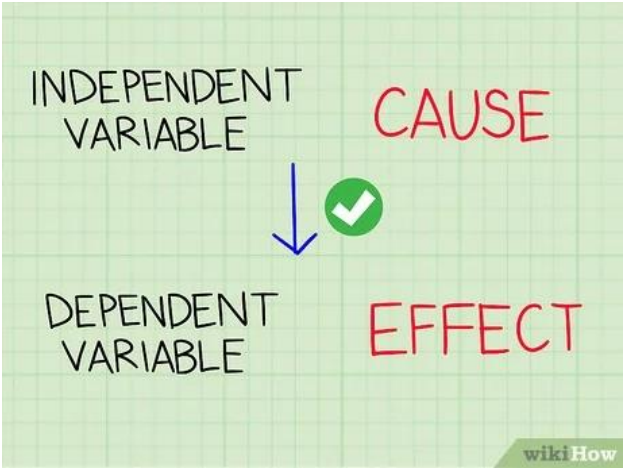
What is Confounding?

$y = 4x + 8h$

dependent variable

independent variables

Confounding Variable



Affects the relationship between the two variables

Independent Variable → **Dependent Variable**

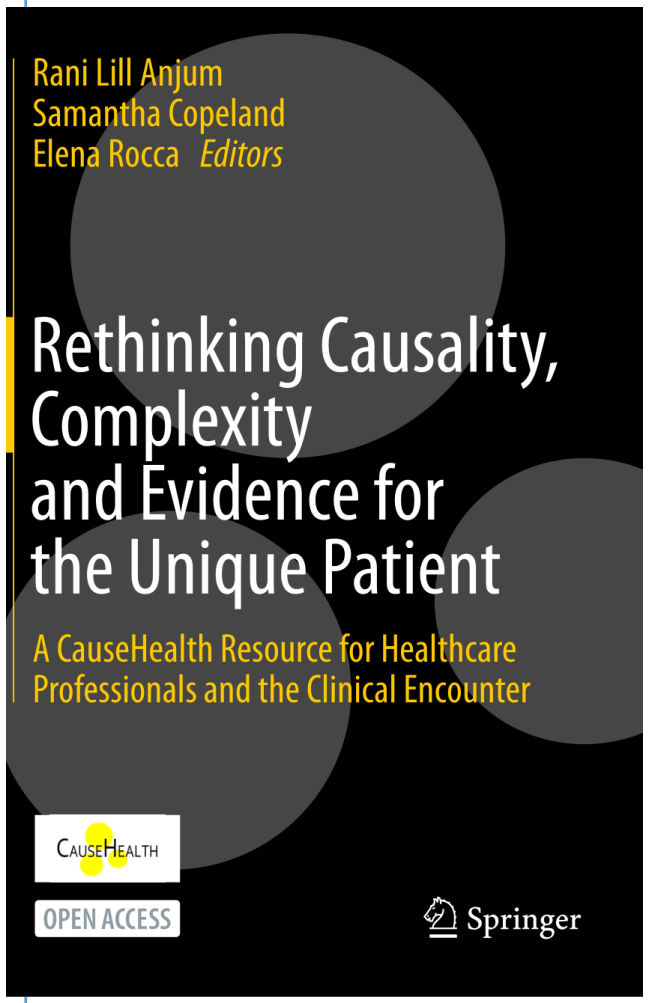
Causality : *A major topic in medicine*

- Causality has always been a major topic in medicine.
- *It is important to know the cause of disease not only to enable the best possible treatment, but also to develop the best possible diagnostic tests.*
- Everyone knows that it is dangerous to treat fever with antibiotics without knowing its cause.
- *But, on the contrary, it is reasonable to withhold treatment because we do not know the cause?*
- That unfortunately, is often the **dilemma** in many medical disciplines.

https://doi.org/10.1016/j.crvi.2019.03.001

Causality : *Complex situations*

- Most everyone would agree that looking for the cause of an event is a natural thing to do.
- ***This is particularly so in medicine.***
- Sometimes the response is simple, unequivocal, for instance when there is an obvious genetic or environmental cause.
- Elsewhere, in more **complex situations**, it is less straightforward.



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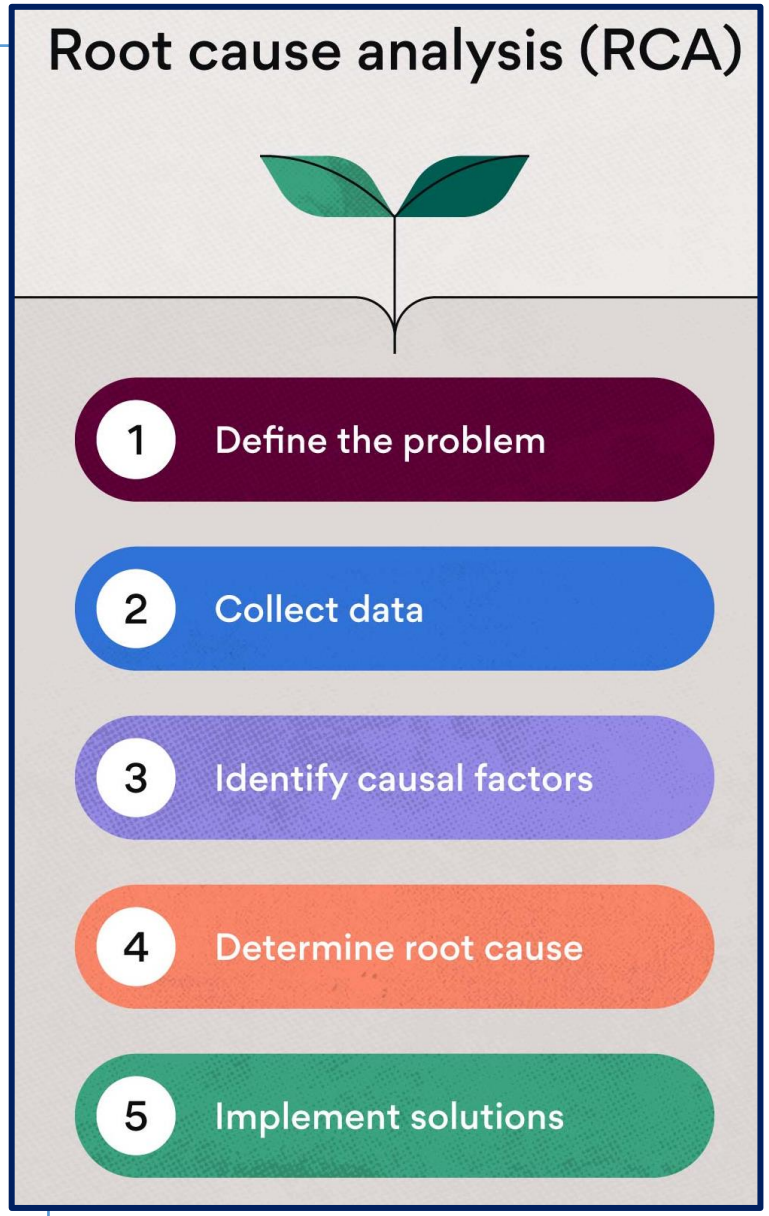
Is an event causal??

- Emphasis is often placed on chronology -the striking effect of a sequence of events- despite the lack of any link to **causality**.
- *This attitude often leads to errors, especially if the public is poorly informed, the side effects of vaccinations being a caricatured example.*
- In other situations, no precise cause can be found. https://doi.org/10.1016/j.crvi.2019.03.001



Finding precise cause is not so easy

- In other situations, no **precise cause** can be found.
- *Indeed, many diseases have a multi-factorial origin associating factors of genetic, epigenetic, and environmental predisposition.*
- The disease is caused, or its progress favored, by a group of factors that, taken individually, have little or no effect.
- Such complex situations are difficult to analyze despite the progress made possible by recent advances in genetics and biology, epidemiology, and other disciplines.

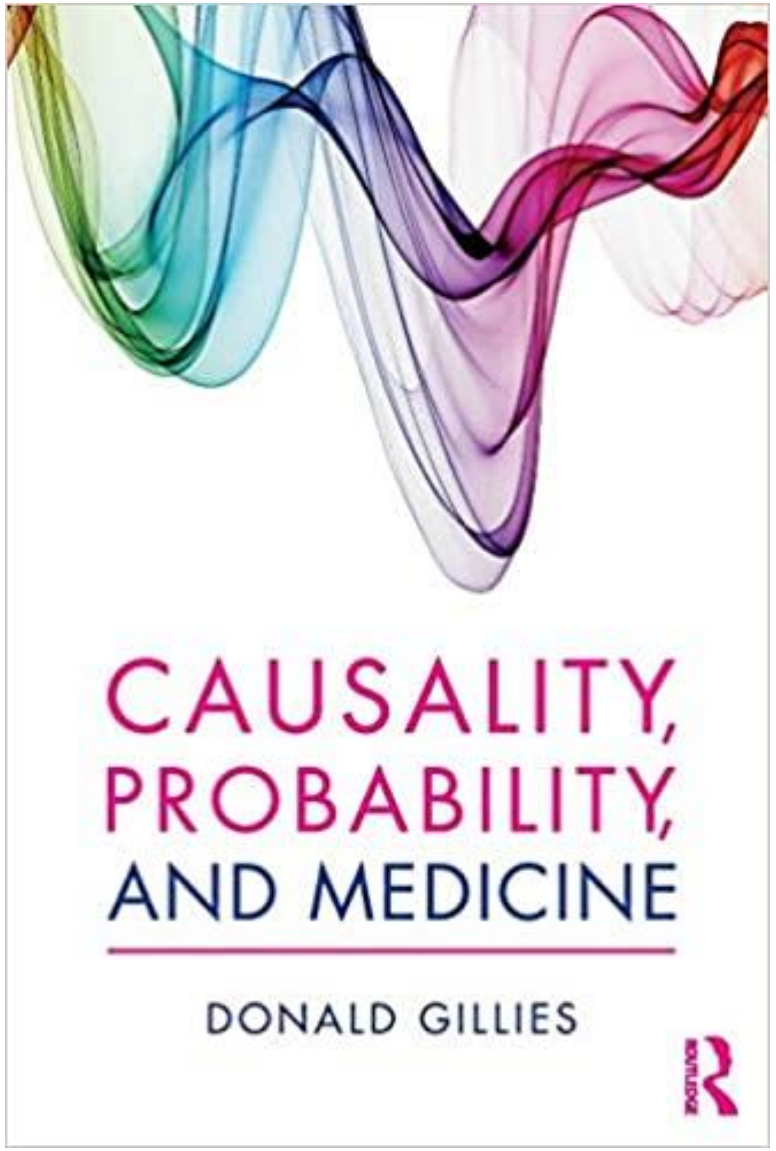
https://doi.org/10.1016/j.crvi.2019.03.001

Principles of Causality

- ***Hill's Criteria of Causation*** **outlines:**
- **Minimal conditions needed to establish a causal relationship between two items**
- **Criteria were originally presented by Austin Bradford Hill (1897-1991), a British medical statistician as a way of determining the causal link between a specific factor (e.g., cigarette smoking) and a disease (such as emphysema or lung cancer)**
- ***Hill's Criteria*** **form the basis of modern epidemiological research**
- **attempts to establish scientifically valid causal connections between potential disease agents and the many diseases that afflict humankind.**

Apparently simple cases

- In certain cases, the situation is apparently very simple, the cause is obvious.
- *Infection is a good example, when the responsible pathogenic agent is known.*
- This is also the case for monogenic diseases when the genetic mutation or anomaly is recognized.
- *However, even in these cases, the situation is not always as simple as it would appear.*



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Causality in contagious infections

- For instance, in contagious infections, we know that not everyone will get the disease during an epidemic, an observation probably related to genetic factors.
- *Nevertheless, the infectious agent is still the cause of the disease, even though only a certain number of individuals with a mutation inducing a particular immune deficiency become ill, generally severely.*
- But this remains exceptional; most carriers of the mutation in question are not susceptible to infectious diseases other than the one associated with the mutation.

https://doi.org/10.1016/j.crvi.2019.03.001

Causality in multifactorial diseases

- Very often, diseases are ***multifactorial***.
- *For the simplest situations, this can correspond to the combined effects of several identified factors, somewhat like an airplane accident where many causes, sometimes five or six, have an additive effect:*
- Each cause taken individually, or even associated with several others, is insufficient to trigger the accident.

https://doi.org/10.1016/j.crvi.2019.03.001

Causality in multifactorial diseases

- ✓ *This type of situation -**the additive effect of external factors**- is well known in medicine.*
- ✓ For example, in **coeliac disease**, ingestion of gluten is a prerequisite for disease expression.
- ✓ *But, of course, symptoms do not develop in everyone who eats **gluten**-containing food.*
- ✓ In fact, for most patients, the situation is much more complex:
- ✓ *Poorly understood interactions occur between genetic and environmental factors.*

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Causality in genetic diseases

- Genetic factors can be expressed in several ways.
- **Predisposition** -*let us hazard the term cause in certain cases*- can be inscribed in the inherited parental genome.
- This is ***hereditary disease***, caused by one or many genes.
- But it must be noted that in the multiple-gene configuration, hereditary familial disease does not occur if the **genetic factor** is expressed insufficiently.
- The role of heredity is thus very limited, but nevertheless very significant.

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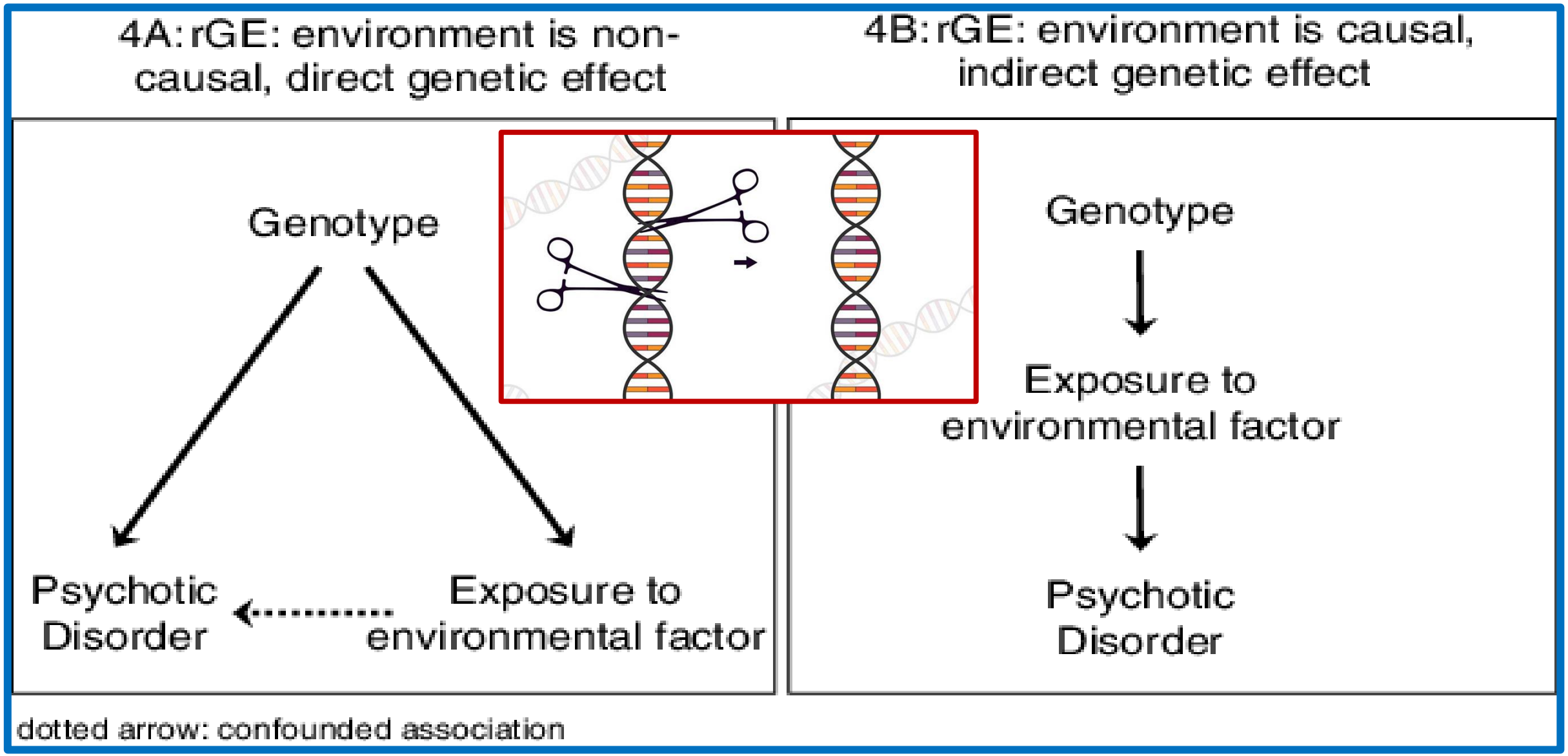
Causality in genetic diseases



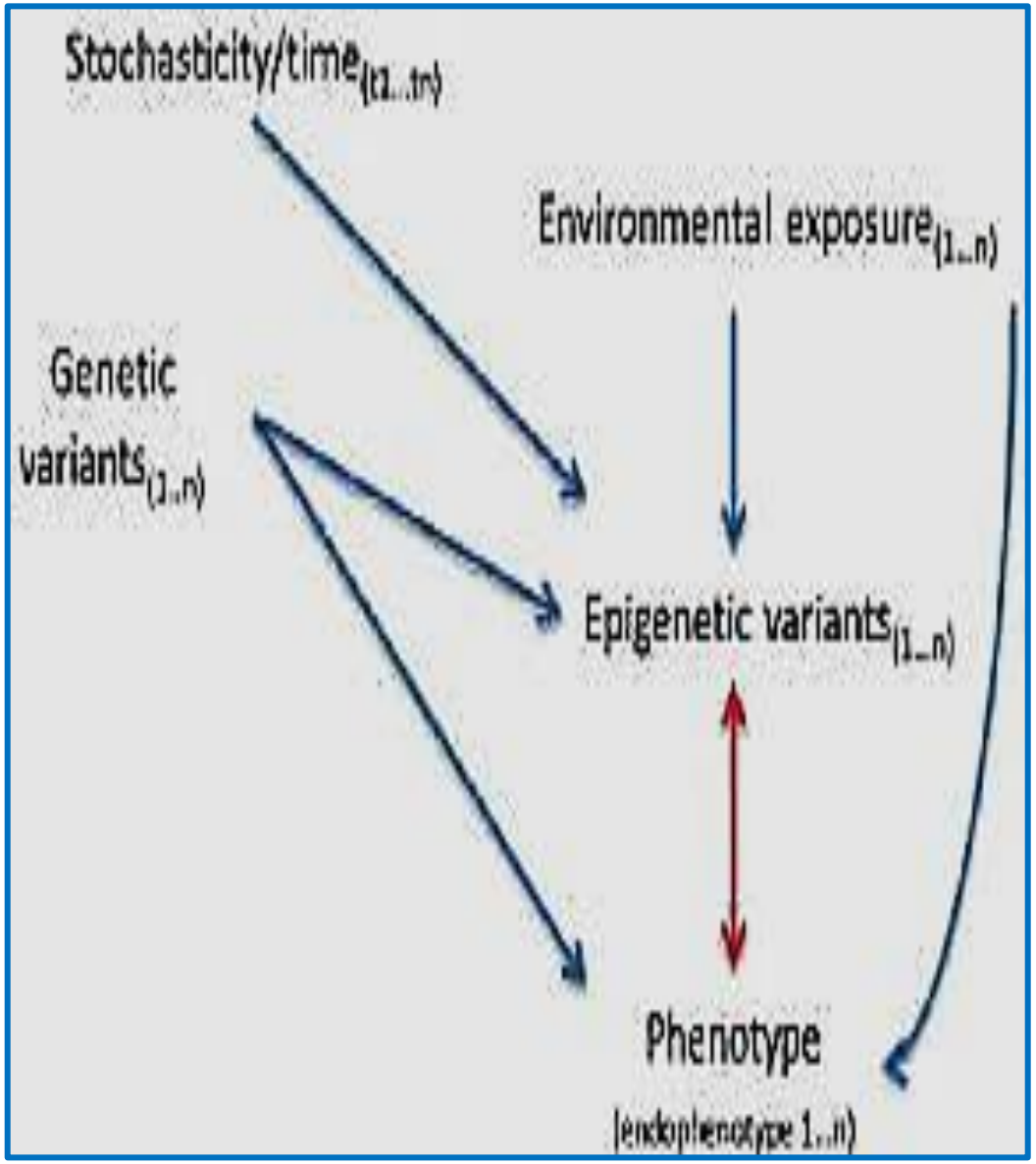
Causality for monogenic diseases

- For monogenic diseases, the question is one of penetrance.
- *In certain configurations all individuals carrying the mutation present the disease, while in others, expression is highly variable from one individual to another, both in terms of severity and age of onset.*
- There are even cases where the disease does not develop despite the presence of the mutation.
- *Many often poorly understood factors can affect penetrance.*
- Epistasis, other genes interacting with the disease-causing mutated gene, may be involved.
- In other situations, environmental factors modulate disease expression.

https://doi.org/10.1016/j.crvi.2019.03.001

Causality in genetic diseases

- The greatest problem we are facing today is to determine which genes and mechanisms support the genetic control of diseases with a hereditary component.
- *The emergence of modern genomic techniques generated great hope.*
- Considerable effort was devoted to the identification of predisposing genes in large cohorts of several thousands of patients using highly sophisticated methods such as ***genome-wide association studies (GWAS)***.



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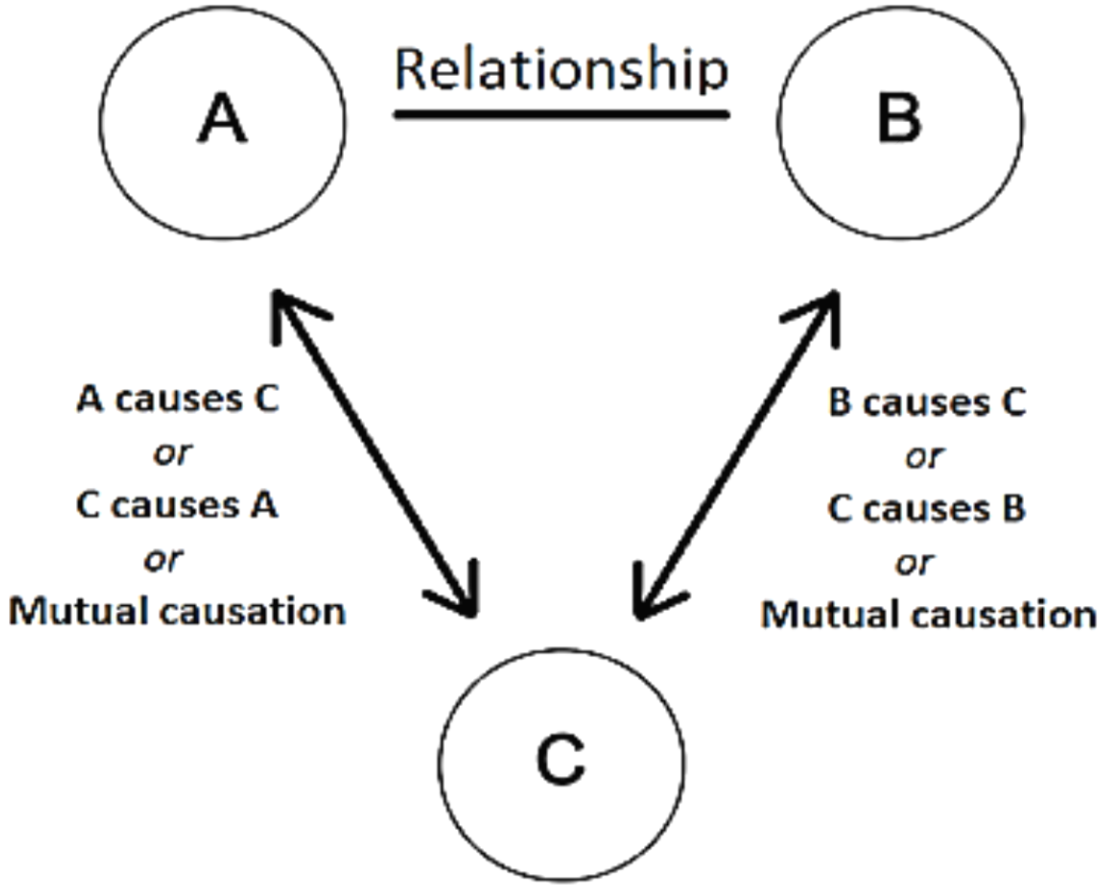
Causality & Environment

- ✓The viral infection may have occurred long before the onset of overt disease, explaining why its stigmata would be so difficult to identify.
- ✓*This causal infection might also be non-specific, i.e. widespread in the general population.*
- ✓The pathogenic process would thus involve a specific individual response to a potentially common viral infection.



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Causality & Environment

- *The effect of the environment is of course crucial, but also very complex.*
- For the ecologist, the environment refers essentially to the physical, chemical or climatic context in which an individual lives.
- *For the geneticist, many other factors are involved, including the group of factors that lead to an interesting fact:*
- Strong heredity in certain polygenic diseases is associated with a rate of concordance between monozygotic twins that rarely exceeds 40-50% despite the fact that monozygotic twins live in a very similar environment, at least during childhood.

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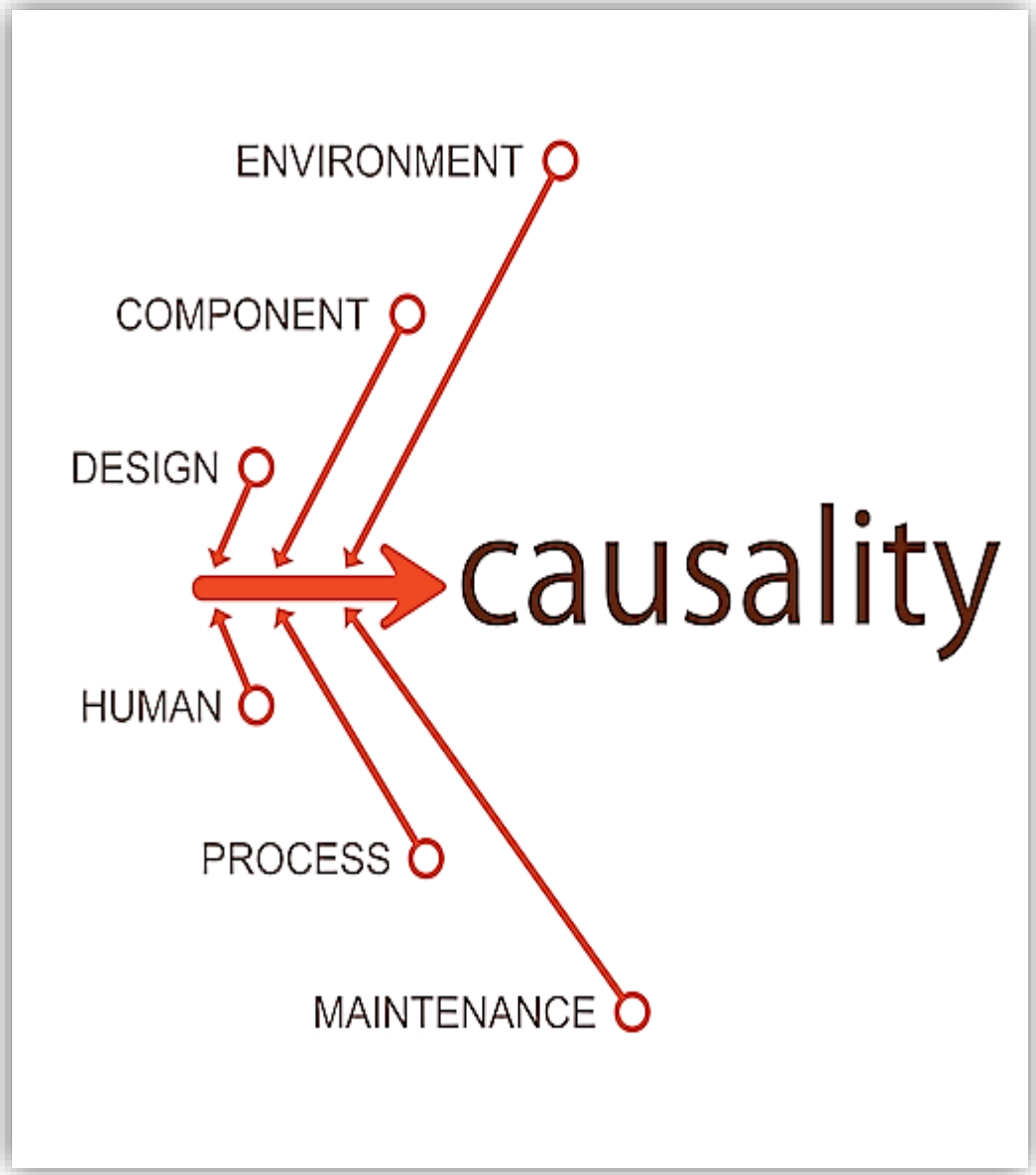
Causality & Environment

- This results from personal factors including individual behavior, in particular dietary habits and use of addictive substances such as alcohol and tobacco.
- *These factors also include interpersonal relations with other individuals, the educational context, and more generally the cultural context.*



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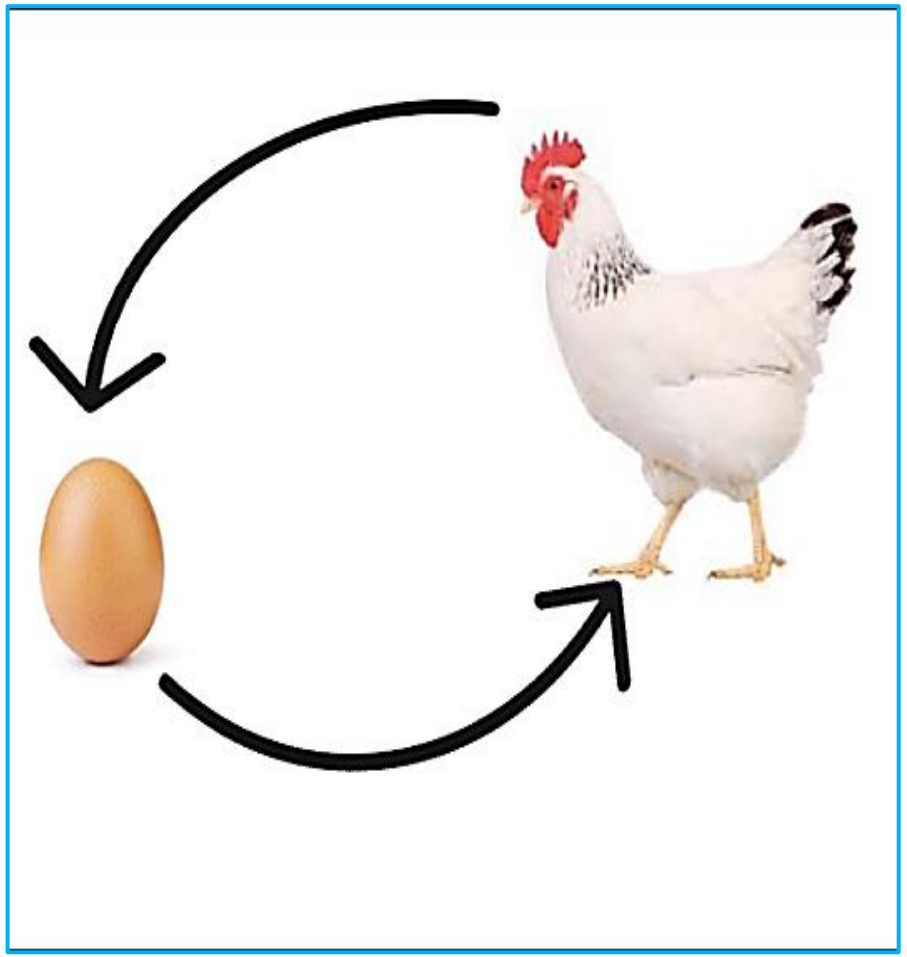
Causality & Environment

- Certain epidemiological, serological or even molecular arguments have been brought together, but are not particularly convincing.
- *The evidence is also uncertain for other autoimmune diseases such as multiple sclerosis, despite the fact that the pathogenic process begins very much like a viral infection that **triggers** autoimmune disease secondarily.*



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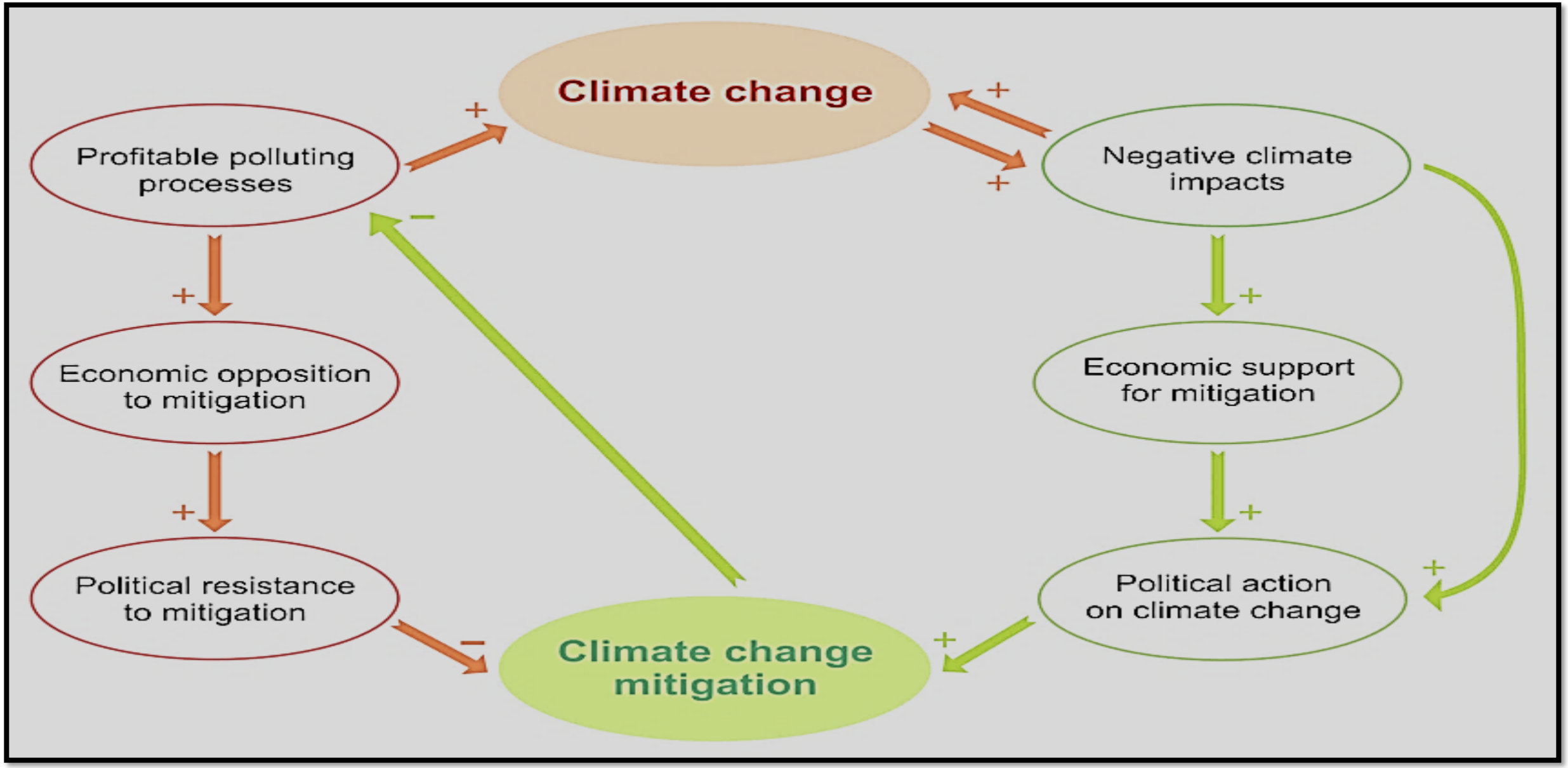
Causality & Environment



A prototype disease : Type 1 DM

- Here, we propose to examine this complexity, illustrating our discussion with the particularly well-documented search for the cause of a prototype disease, IDDM / ***insulin-dependent diabetes mellitus*** (Type 1 DM).

- *The role of environment in the genesis of* **insulin-dependent diabetes** *has been the object of extensive study. Over the last 20 years, a large body of work has been devoted to the search for a viral cause. Particular attention has been given to Coxsackie-type enterovirus.*

https://doi.org/10.1016/j.crvi.2019.03.001

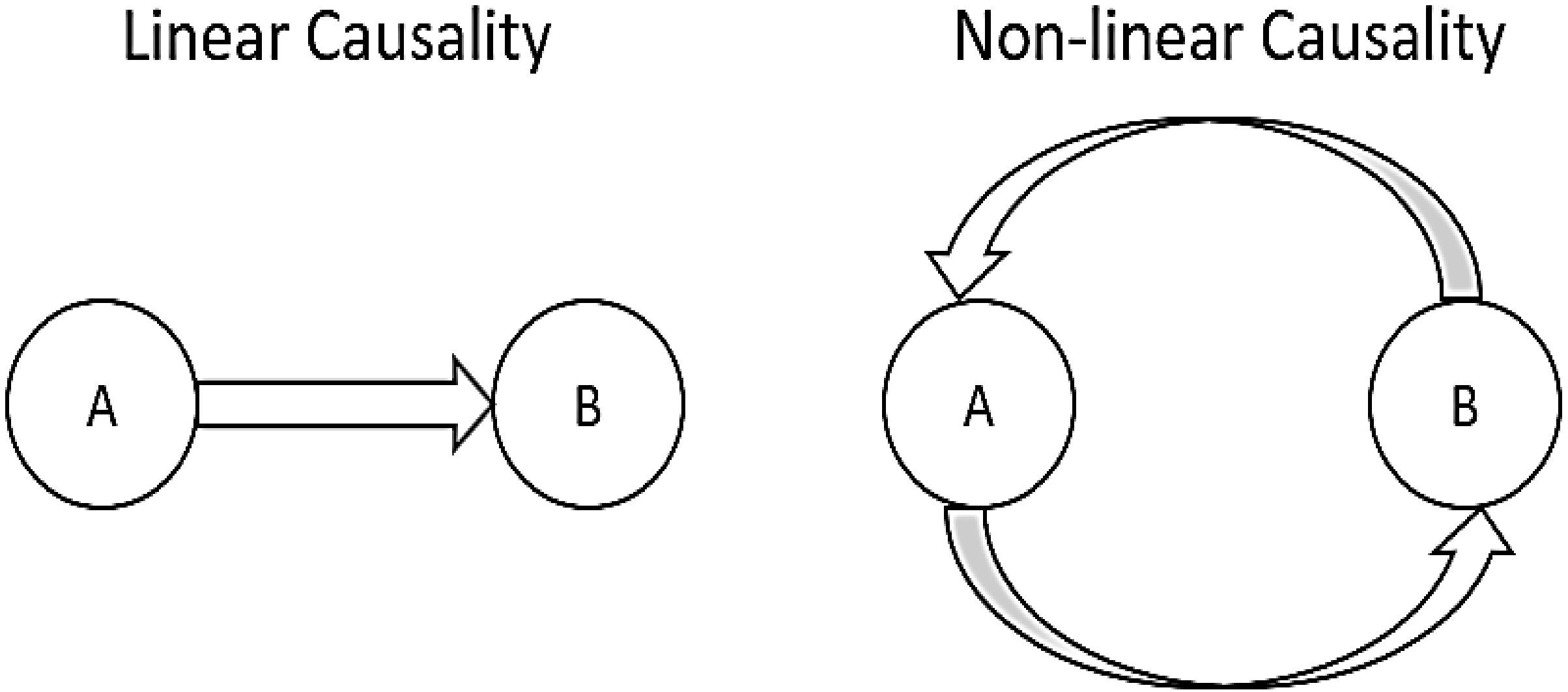
Deterministic Causality

EXAMPLE OF SUFFICIENT CAUSE

Sufficient causes are very rare in medicine, because it is exceptional that one exposure is by itself enough to cause disease. Usually exposures are much more common than the diseases they cause. Only about 5% of people who smoke get lung cancer. The measles virus virtually always causes people to get clinical measles, and rabies infection is always fatal.

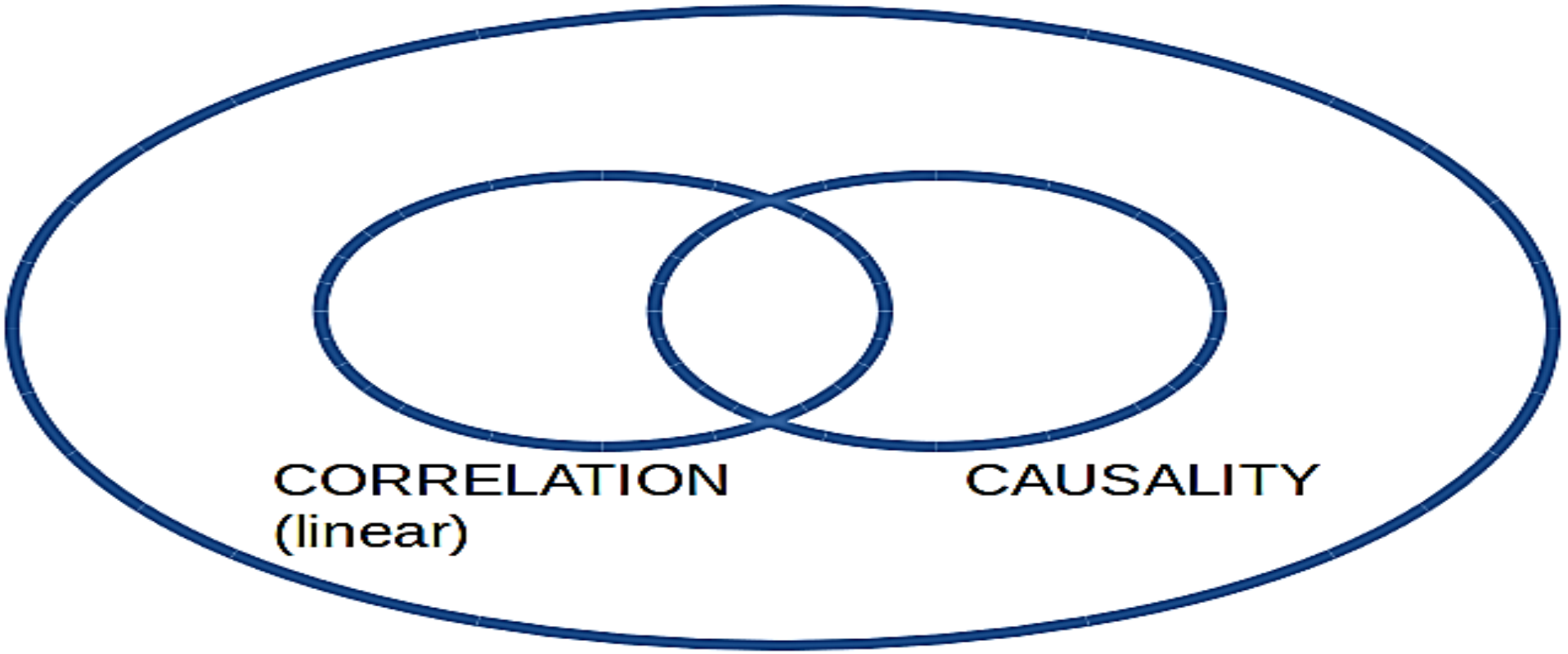
10 minutes

Linear & Non-Linear Causality



Correlation & Causality

Correlation is defined as the statistical association between two variables.



Correlation & Causality

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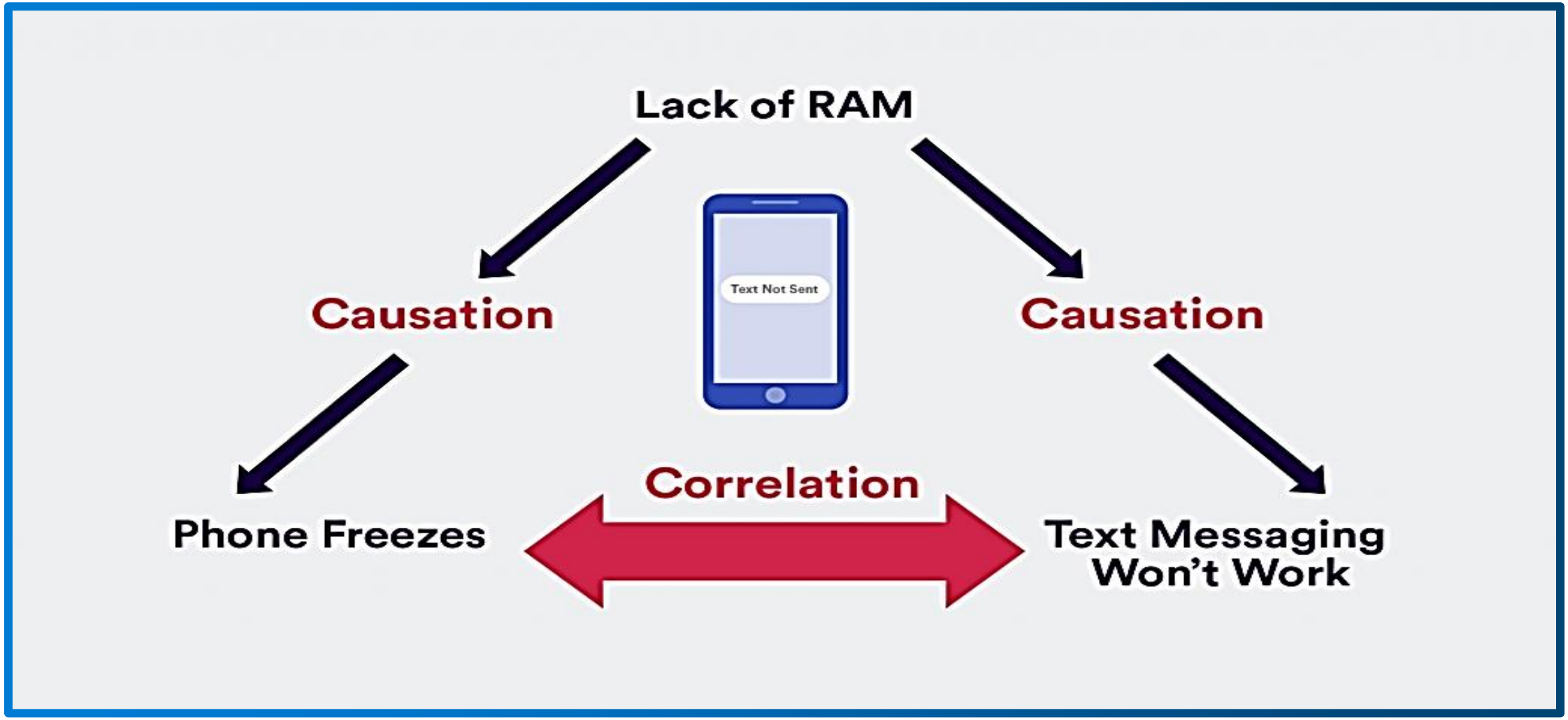


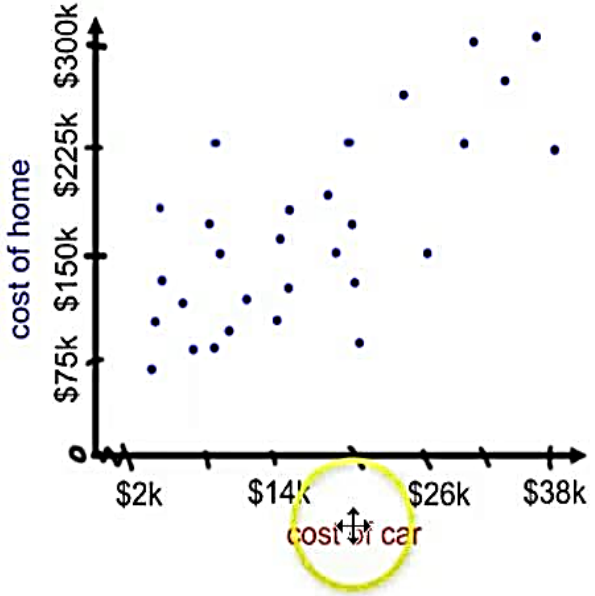
Correlation & Causality

Correlation is defined as the statistical association between two variables.

correlation

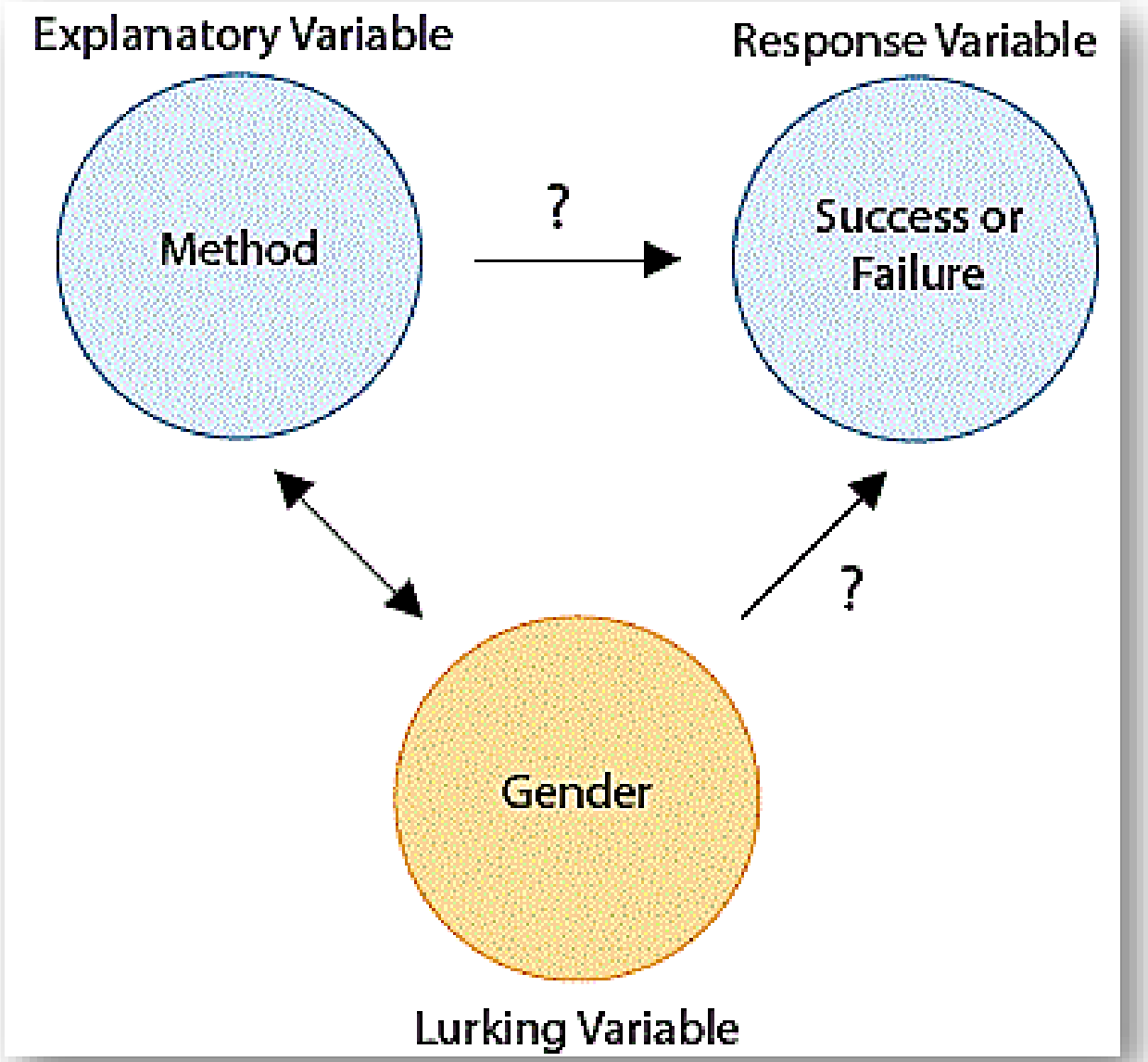
$\neq$

causation



A correlation between variables, however, does not automatically mean that the change in one variable is the cause of the change in the values of the other variable. **Causation** indicates that one event is the result of the occurrence of the other event; i.e. there is a ***causal relationship*** between the 2 events.

Variables for causal inference



Does simple linear regression imply causation?

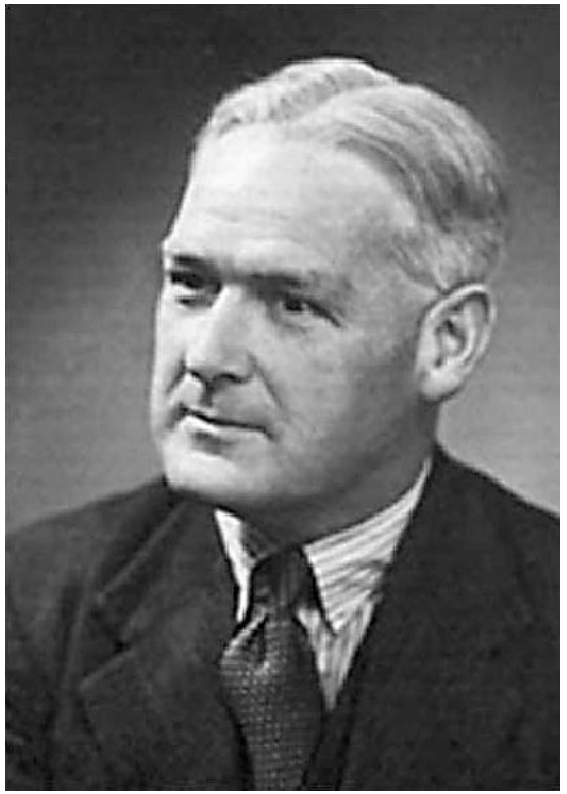
Correlation does not imply causation but instead the strength and direction of the relationship.

There is nothing explicit in the mathematics of **regression** that state causal relationships, and hence one need not explicitly interpret the slope *(strength and direction)* nor the **p-values** (i.e. the probability a relation as strong as or stronger would have been observed if the relationship were zero in the population) in a **causal** manner.

Criteria for Causal Association

Bradford Hill's criteria for making causal inferences-

1. Strength of association
2. Dose-Response relationship
3. Lack of temporal ambiguity
4. Consistency of findings
5. Biologic plausibility
6. Coherence of evidence
7. Specificity of association



Temporal Association

- Exposure to causative factor must occur before the onset of disease.
- This criteria is basic to the causal association.
- Establishment of temporal association is easy in acute communicable diseases
- It is difficult to establish temporal sequence in chronic insidious non communicable diseases as to which came first.
- The consumption of cigarette smoking preceded by 30 years to the increase in the death rates due to lung cancer. Theses observations are compatible with the long latent period pathogenesis of carcinogenesis .

Hill's Criteria for Causal Relation

- Strength of association
- Consistency of findings
- Specificity of association
- Temporal sequence
- Biological gradient (dose-response)
- Biological plausibility
- Coherence with established facts
- Experimental evidence

3 criteria for causality

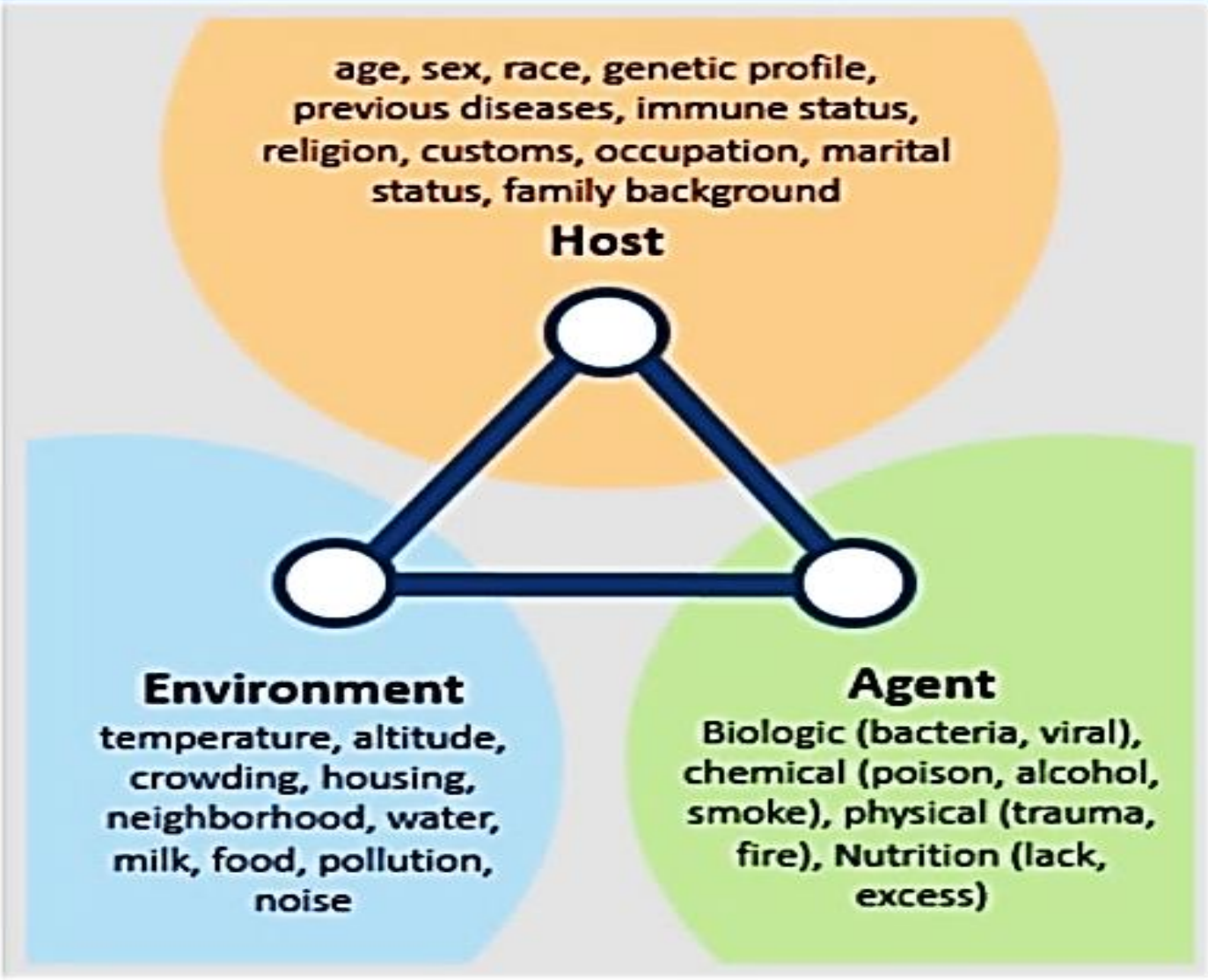
X causes Y if:

- X precedes Y in time
- X and Y are statistically associated
- All other potential causes of Y have been ruled out.

Which of the following factors is needed to establish causality?

Epidemiological Triangle

- Basic model to study health problems
- 3 factors
  - Host
  - Environment
  - Agent
- Disease is produced by exposure of a susceptible host to an noxious agent in the presence of environmental factors that aid or hinder agents of disease

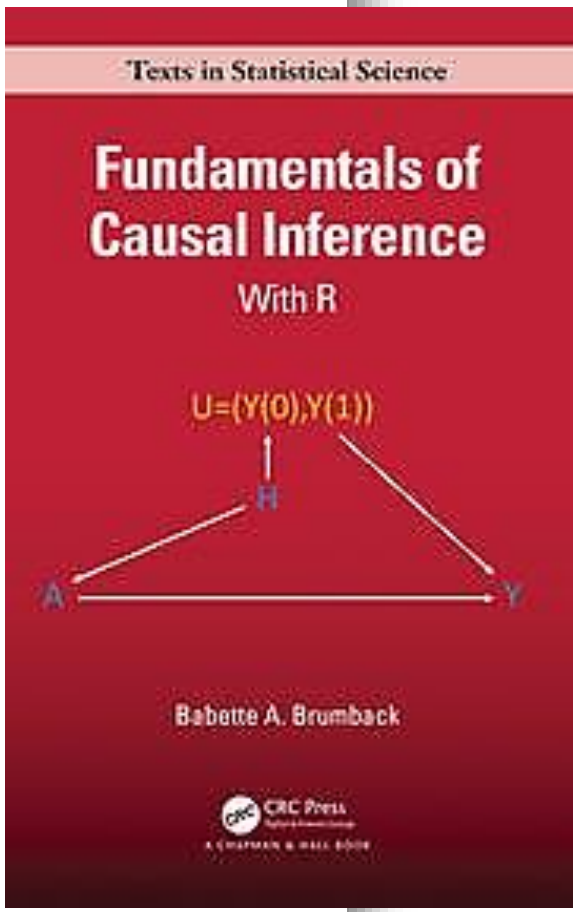


Causal Inference in Epidemiology

Bridging the gap between our ideas and our observations.

Criteria:

- Strength of association
- Consistency of findings
- Specificity of association
- Temporality (lack of ambiguity)
- Biologic gradient (dose-response effect)
- Biologic plausibility of the hypothesis
- Coherence of evidence
- Experimental evidence



Introducing Do Why

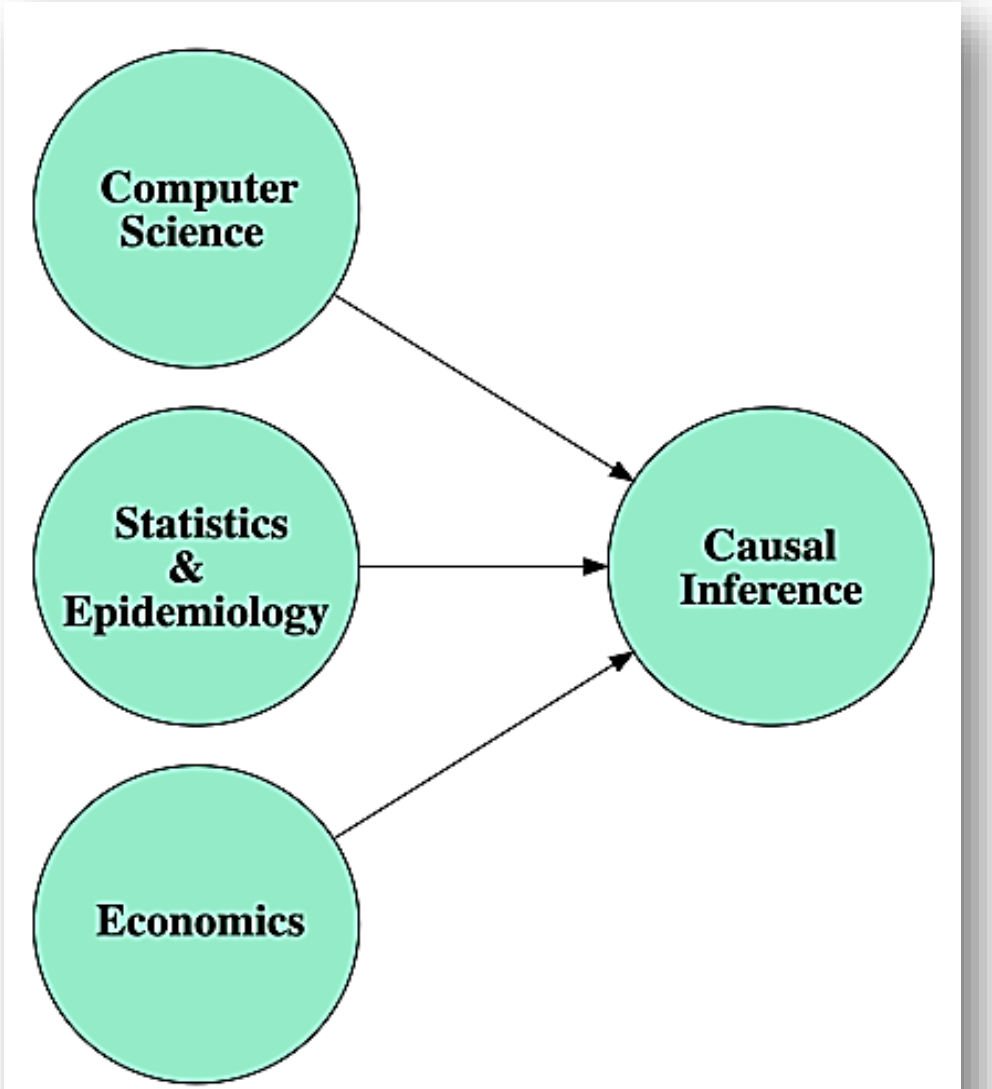
The human mind has a remarkable ability to associate causes with a specific event. *From the outcome of an election to an object dropping on the floor, we are constantly associating chains of events that cause a specific effect.* Neuropsychology refers to this cognitive ability as **causal reasoning**. *Computer science and economics study a specific form of* ***causal reasoning*** *known as* ***causal inference*** *which focuses on exploring relationships between two observed variables*. Over the years, ***machine learning*** has produced many methods for ***causal inference*** but they remain mostly difficult to use in mainstream applications. Recently, Microsoft Research open sourced DoWhy, a framework for ***causal thinking and analysis***.

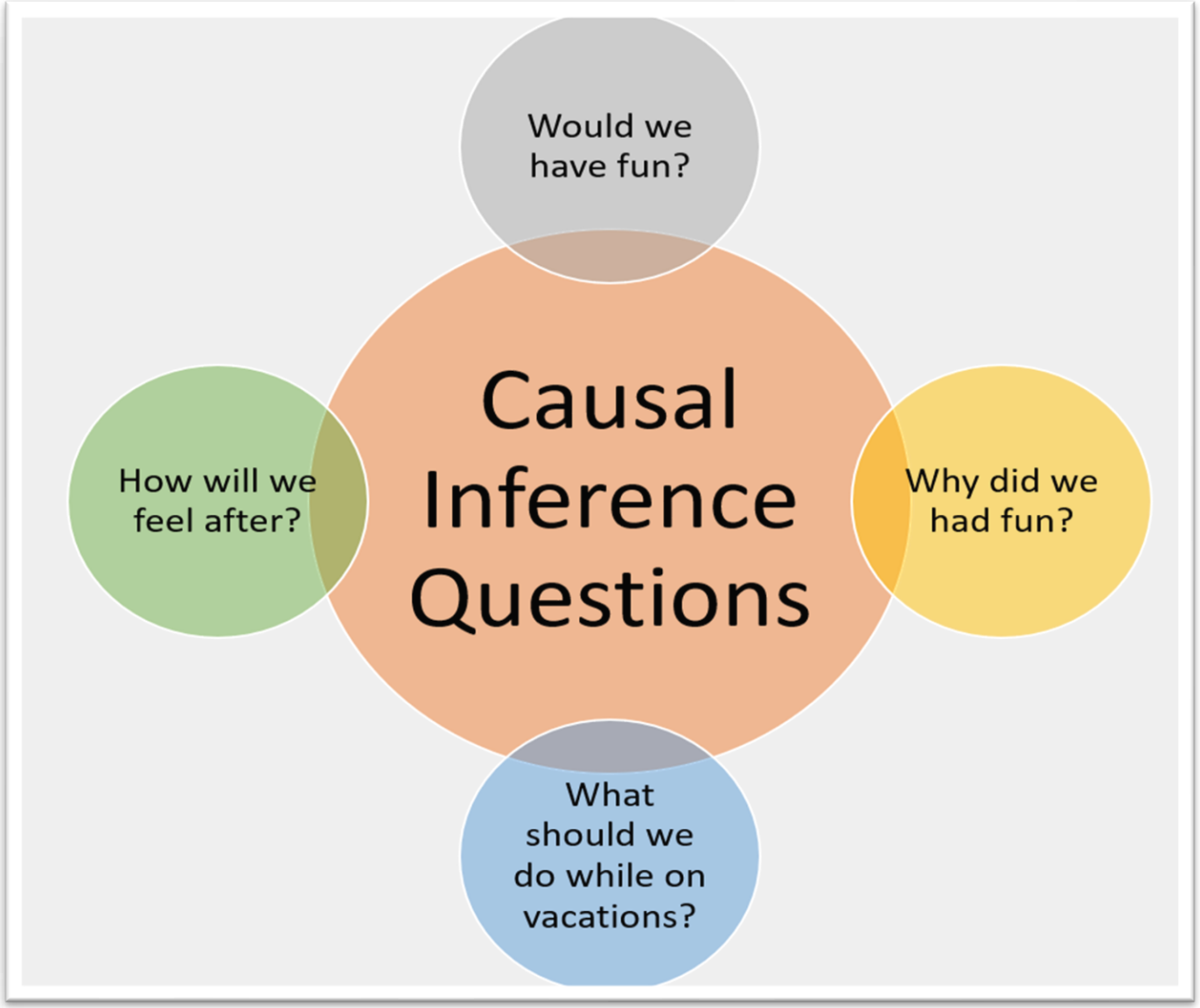
The challenge with causal inference

The challenge with ***causal inference*** is not that is a new discipline, quite the opposite, but that the current methods represent a very small and simplistic version of ***causal reasoning***. Most models that try to ***connect causes*** such as linear regression rely on empirical analysis that makes some assumption about the data. **Pure causal inference** relies on counterfactual analysis which is a closer representation to how humans make decisions. Imagine a scenario in which you are traveling with your families for vacations to an unknown destination. Before and after the vacation you are wrestling with a few counterfactual questions:

1.https://towardsdatascience.com/introducing-dowhy-cc58b75d61ac

Causal Inference & Questions





https://aiws.net/practicing-principles/modern-causal-inference/augmenting/on-media-augmenting/introducing-dowhy/

The bradford hill criteria is the necessary set of criteria which is needed to establish a causal relationship

Temporality

reversibility

plausibility- is it consistent with other knowledge

consistency- have similar results been shown in other studies

strength- what is the strength of association

dose dependent relationship/ biological relationship- does the effect increase with

BRADFORD-HILL'S CAUSAL CRITERIA

Strength of association

Temporal relationship

Consistency

Specificity

Dose-response relationship/ Biological gradient

Biological plausibility

Coherence

Experiment

Anology

Strength of associaion within Hill's criteria

- **Strength of association** within Hill's criteria of causality means that the larger the association between an exposure and an outcome,
- *The more likely it is that the exposure causes the outcome.*
- In other words, a **strong association** means that there is a big difference in the risk or rate of the outcome between the exposed and unexposed groups.
- *For instance, if smoking increases the risk of lung cancer by 2,300% for men and 700% for women, then this is a very strong association that suggests a causal relationship.*

Applying the Bradford Hill criteria in the 21st century: how data integration has changed causal inference in molecular epidemiology | Emerging Themes in Epidemiology | Full Text (biomedcentral.com) *01.10.23*

Temporal relationship within Hill's criteria

- **Temporal relationship** within Hill's criteria of causality means that the cause must occur before the effect.
- *In other words, the exposure to the factor that is suspected to cause the disease must have happened before the disease developed.*
- This criterion helps to establish a logical sequence of events and to rule out reverse causation, which is when the disease causes the exposure instead of the other way around.
- *For example, if we want to test whether smoking causes lung cancer, we need to make sure that the smokers in our study started smoking before they were diagnosed with lung cancer. Otherwise, we might be misled by the possibility that some people with lung cancer started smoking to cope with their condition.*

Hill's Temporality Criterion: Reverse Causation and Its Radiation Aspect | SpringerLink *01.10.23*

Consistency within Hill's criteria of Causality-1

- **Consistency** within Hill's criteria of causality means that when there is a real, causal connection, the result should be ***repeatable***.
- *In other words, different studies using different methods and populations should find the same or similar association between* ***the cause and the effect****.*
- For instance, if smoking causes lung cancer, then we would expect to see a consistent relationship between smoking and lung cancer in different countries, time periods, and study designs.

ACSH Explains 'Hill's Criteria': Determining Causality from Correlation | American Council on Science and Health *01.10.23*

Consistency within Hill's criteria of Causality

- *A concrete sample for this criterion is the [**Lung Health Study**], which followed more than 5,000 **smokers** for five years and found that those who quit smoking had a lower risk of lung cancer than those who continued to smoke.*
- This finding was **consistent** with previous studies that also showed a ***causal link*** between smoking and lung cancer.

ACSH Explains 'Hill's Criteria': Determining Causality from Correlation | American Council on Science and Health 01.10.23

Specificity within Hill's criteria of Causality

- **Specificity** within Hill's criteria of causality means that a single specific putative cause produces a specific effect.
- *In other words, the exposure to the factor that is suspected to cause the disease is only associated with that disease and not with other diseases.*
- This criterion helps to rule out confounding factors and alternative explanations.
- *For example, if we want to test whether **asbestos** exposure causes **mesothelioma**, a rare type of cancer that affects the lining of the lungs, we need to make sure that asbestos exposure is not associated with other types of lung cancer or other diseases.*

ACSH Explains 'Hill's Criteria': Determining Causality from Correlation | American Council on Science and Health *01.10.23*

Dose-response relationship & Hill's criteria

- **Dose-response relationship** within Hill's criteria of causality means that an increasing amount of exposure to an agent, either in amount or duration, increases the risk of disease.
- *In other words, the more a person is exposed to the factor that is suspected to cause the disease, the higher the probability or severity of the disease.*
- This criterion helps to establish a quantitative relationship between the cause and the effect and to rule out chance or confounding factors.
- *For example, if we want to test whether alcohol consumption causes liver cirrhosis, we need to measure how much and how often a person drinks alcohol and compare it with the incidence and severity of liver cirrhosis.*
- *A concrete sample for this criterion is the [**Global Burden of Disease Study**], which estimated the risk of death and disability from various diseases and injuries for different levels of alcohol consumption in 195 countries and territories from 1990 to 2016*

ACSH Explains 'Hill's Criteria': Determining Causality from Correlation | American Council on Science and Health *01.10.23*

Biological plausibility & Hill's criteria of Causality

- **Biological plausibility** within Hill's criteria of causality means that there is a reasonable biological mechanism to explain why the exposure causes the outcome.
- *In other words, the association between the cause and the effect should be consistent with the current understanding of the biological processes and pathways involved.*
- For example, if we want to test whether smoking causes lung cancer, we need to have some evidence that smoking can damage the DNA of lung cells and trigger mutations that lead to cancer.
- *A concrete sample for this criterion is the [Lung Health Study], which followed more than 5,000 smokers for five years and found that those who quit smoking had a lower risk of lung cancer than those who continued to smoke.*
- This finding was consistent with previous studies that also showed a causal link between smoking and lung cancer

ACSH Explains 'Hill's Criteria': Determining Causality from Correlation | American Council on Science and Health *01.10.23*

Coherence & Hill's criteria of Causality

- **Coherence** within Hill's criteria of causality means that the association between the exposure and the outcome should be compatible with the existing knowledge and theory in the field of study.
- *In other words, the cause and the effect should make sense in light of the biological, clinical, or epidemiological context.*
- For ex. if we want to test whether vitamin C deficiency causes scurvy, we need to have some evidence that vitamin C plays a role in the synthesis of collagen, which is essential for the health of connective tissues.
- A concrete sample for this criterion is the [James Lind's Experiment], which was one of the first clinical trials in history that tested the effect of ***citrus fruits on scurvy*** among sailors in 1747.

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Experiment & Hill's criteria of Causality-1

- **Experiment** within Hill's criteria of causality means that the relationship between the exposure and the outcome can be tested by manipulating the exposure in a controlled setting.
- *In other words, the exposure can be randomly assigned to a group of subjects and compared with another group that does not receive the exposure or receives a different level of exposure.*
- This criterion helps to establish a causal inference by minimizing confounding factors and reverse causation.

Experiment & Hill's criteria of Causality-2

❖**For example**, if we want to test whether vitamin D supplementation reduces the risk of respiratory infections, we need to conduct a *randomized controlled trial (RCT)* in which some participants receive vitamin D pills and others receive **placebo** pills.

❖A concrete sample for this criterion is the [Vitamin D to Prevent Acute Respiratory Infection (VIVARI) Trial], which was a multicenter, double-blind, placebo-controlled RCT that enrolled more than 5,000 adults in New Zealand and Australia between 2015 and 2019

ACSH Explains 'Hill's Criteria': Determining Causality from Correlation | American Council on Science and Health 01.10.23

Analogy & Hill's criteria of causality

- **Analogy** within Hill's criteria of causality means that a similar association has been observed in different circumstances or with different agents.
- *In other words, the exposure and the outcome should have some resemblance to other known causal relations.*
- This criterion helps to support the biological plausibility and coherence of the association by providing examples or analogies from other fields or studies.
- **For example**, if we want to test whether Zika virus causes microcephaly, a condition in which a baby's head is smaller than expected, we can use the analogy of other viruses that are known to cause birth defects, such as rubella and cytomegalovirus. A concrete sample for this criterion is the [***Zika Virus and Birth Defects*** — Reviewing the Evidence for Causality] study, which was a systematic review of the available evidence on the association between Zika virus infection and microcephaly and other birth defects in 2016.

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QUICK REMINDERS for & Hill's criteria of causality-1

1. **Causality** in medicine is the study of the relationships between causes and effects of diseases, treatments, and interventions.
2. ***Causality in medicine is not always easy to establish, because there may be many factors that influence the outcome of interest, such as confounding variables, reverse causation, chance, bias, and ethical issues.***
3. **Causality** in medicine can be supported by different types of evidence, such as observational studies, randomized controlled trials, systematic reviews, and meta-analyses. However, each type of evidence has its own strengths and limitations, and no single type of evidence can prove causality definitively.

QUICK REMINDERS for & Hill's criteria of causality-2

4. **Causality** in medicine can be evaluated by using various criteria, such as the ***Hill criteria***, which include *temporality, strength, consistency, biological plausibility, specificity, analogy, experiment, and coherence*. These criteria are not rules or tests, but rather guidelines or considerations that help to assess the causal inference.

5. ***Causality*** *in medicine can be influenced by the level of analysis, such as individual or population level. For example, smoking may cause lung cancer at the individual level, but not at the population level if there are other factors that affect the incidence of lung cancer in different populations.*

QUICK REMINDERS for & Hill's criteria of causality-3

6. **Causality** in medicine can be expressed by using different terms, such as necessary and sufficient causes, contributory causes, risk factors, protective factors, and modifiers. These terms describe the different roles and effects that a cause can have on an outcome.

*7. **Causality** in medicine can be modeled by using different methods, such as causal diagrams, counterfactuals, potential outcomes, and **causal inference**. These methods help to visualize and quantify the causal relationships and estimate the causal effects.*

8. **Causality** in medicine can be challenged by various sources of uncertainty, such as measurement error, missing data, confounding bias, selection bias, information bias, and publication bias. These sources of uncertainty can affect the validity and reliability of the ***causal inference*.**

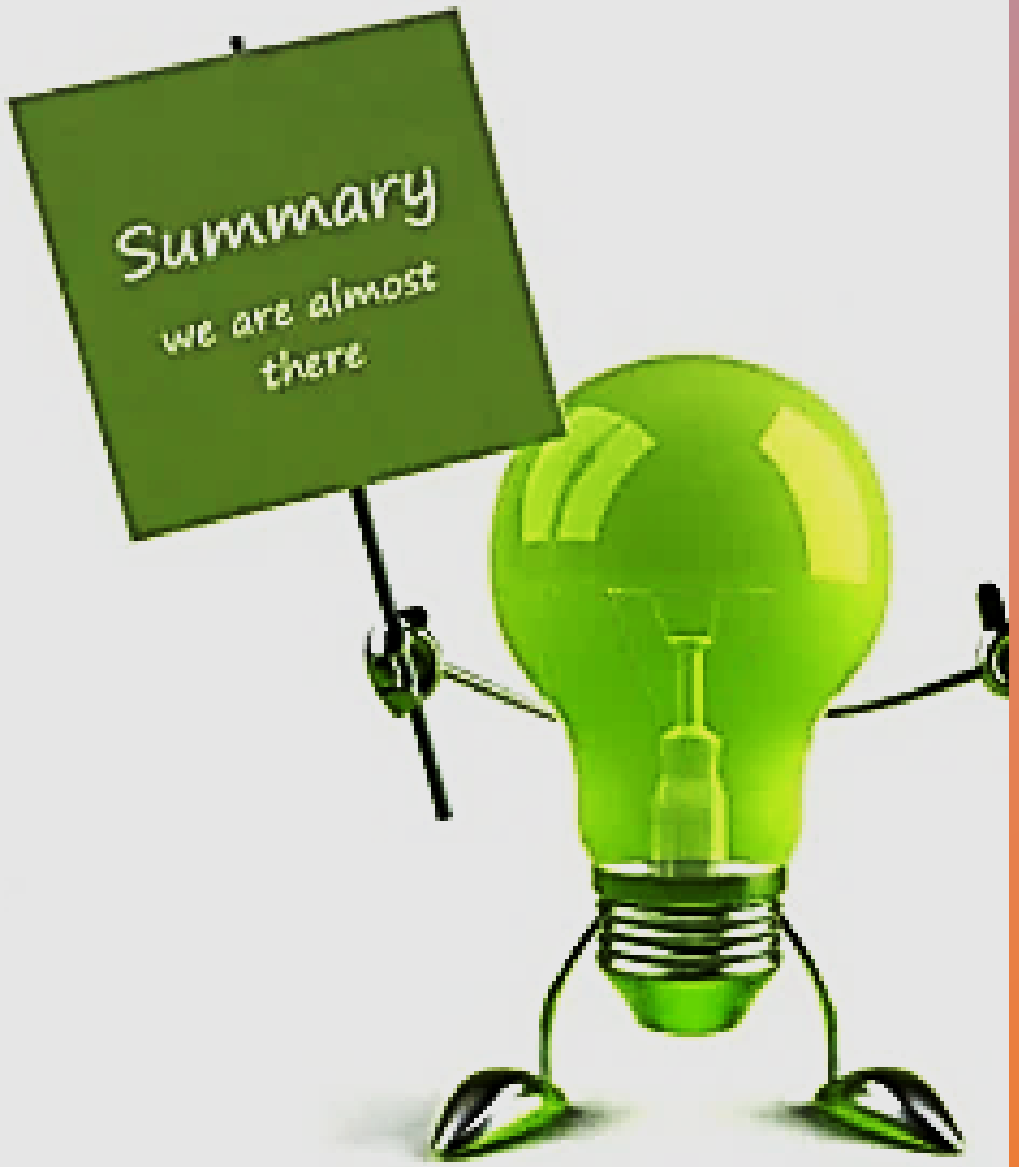
QUICK REMINDERS for & Hill's criteria of causality-4

9. **Causality** in medicine can be improved by using various strategies, such as randomization, blinding, matching, stratification, adjustment, sensitivity analysis, and meta-analysis.
These strategies help to reduce or control the sources of ***uncertainty*** and increase the precision and accuracy of the **causal inference**.

10. ***Causality*** *in medicine can be communicated by using various formats, such as tables, graphs, statistics, narratives, and recommendations.*
These formats help to convey the main findings and implications of the ***causal inference*** *to different audiences and stakeholders.*

Summary:

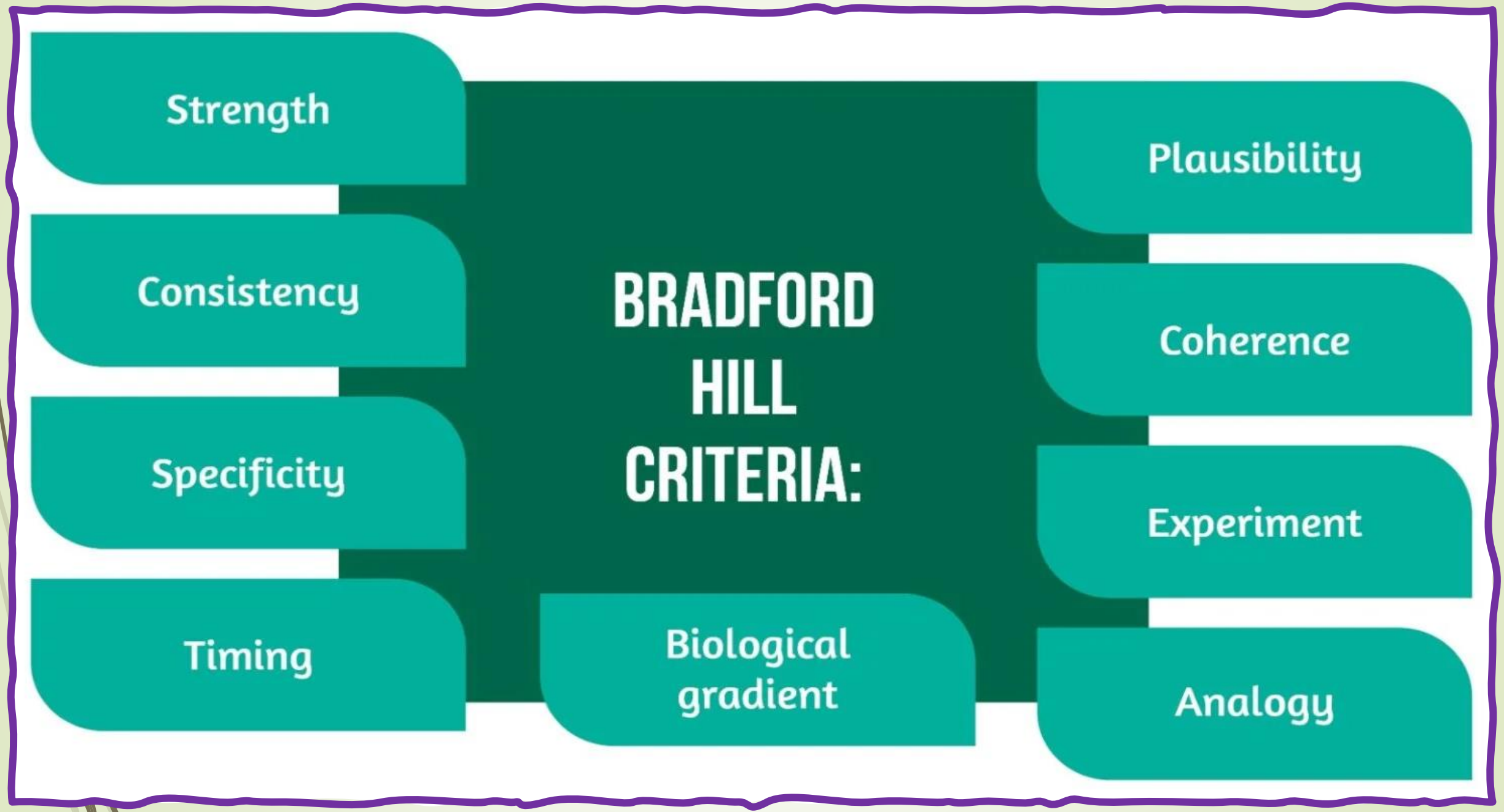
- Association in epidemiological studies and its types
- Causal association
- Bradford Hill's criteria for causal association



Course Summary

At the end of this course, you're expected have learned to :

- describe the meaning of association and its types
- *define Causal and Non-Causal types of association*
- identify confounding factors and how to eliminate
- *recognize the core functions of causal association and inference*
- describe the differences between associaton and correlation
- *list B. Hill's criteria for Causal Relationship / Association*
- realize how functions Causality and causal / primary relationship in Epidemiology & Public Health


Strength
Consistency
Specificity
Timing
BRADFORD HILL CRITERIA:
Biological gradient
Plausibility
Coherence
Experiment
Analogy

Any QUESTIONS?
or COMMENTS??

f o r

Thank you for joining..

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