Introduction to epidemiology2 : cause & effect relationship, multiple causality, correlation & causation = 初歩の疫学2

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Introduction to epidemiology 2

初歩の疫学２

https://jica-health.blogspot.com/2015/10/intro-to-epidemiology-cause-effect.html

Intro to Epidemiology 1

Cause & effect relationship, multiple causality, correlation & causation

This time, I will talk about causality, cause and effect relationship.

1. What is causality?

Causality is the relation between an event (the cause) and a second event (the effect), where the first event is understood to be responsible for the second. Causality (cause and effect relationship) is also the relation between a set of factors (causes) and a phenomenon (the effect).

Causality is important notion in epidemiology as well as our daily life. Causality leads to causal thinking. German philosopher Kant mentioned causal thinking as, "Everything that happens (begins to be) presupposes something from which it follows in accordance with a rule".

Causal thinking (and/or cause-and-effect knowledge) permits rational plans and actions to interrupt the links between the factors causing disease and disease itself. It can help to predict the outcome of an intervention and help to treat disease.

2. Basic expression of causality

Let us first express a very basic cause and effect relationship, a straight relationship,
using basic logical symbol; ⇒, arrow.

a cause ---------> an effect

Cause A ----------> Disease B

A -----------> B

Well, what is a cause? A cause is something which has an effect. In epidemiology, a cause is something that alters the frequency of disease, health status, or associated factors in a population. In real world, causality is usually not so simple and straight. The actual causality is often expressed as a web of causes and the effect.

3. Historical aspects

1) Ancient reasoning/historical aspects

Causal thinking is embedded in the development of humanity. This figure shows the Illustrated Sutra of Cause and Effect (因果応報), 8th century in Japan. Here, the cause is represented as “因 (因縁 or 原因)". The effect is represented as “果 (果報 or 結果 or 報い)". The logic of this relationship is 応報, the Buddhist logic that doinggoods is payed off.

2) Learning from immature reasoning/historical aspects

In early historical time, notion of causality and epidemiological reasoning was immature and mostly erroneous. However, immature reasoning was sometimes still effective and contributed to improve public health status.

Example 1: Miasma --------> cholera.

The miasma theory, that diseases were caused by a miasma ("bad air", "night air"). was accepted from ancient times in Europe, India, and China. This reasoning is wrong. However, in 19th century, the delivery of clean water and the improvement of the sanitary condition of home and workplace were driven by the miasma theory.

Example 2: contagion -----> Plague

Contagion means disease transmission by direct or indirect contact. This hypothesis sounds reasonable. However, because of the wrong political application of this, Jews were incriminated in a poorly understood causal pathway of contagion and thousands were executed to control plague.

3) Initial approach in Western philosophy//historical aspects

Historically, philosophers have approached to the nature of causality. For example, Aristotle identified four elements to cause.

Material cause, the material whence a thing has come or that which persists while it changes.
Formal cause, whereby a thing's dynamic form or static shape determines the thing's properties and function.
Efficient cause, which imparts the first relevant movement.
Final cause, the criterion of completion, or the end.

4. Multiple causality

1) Introduction/multiple causality

The hypothetical causal model between A and B, such as ”A ---> B" (A causes B), is simple and straightforward.

In order to clarify epidemiological hypothesis, especially in research settings, we welcome such simple model. However, in the real world setting, "one cause – one effect" understanding is a simplistic mis-belief. We often face more complicated situation that involve multiple causes and multiple effects. Disease are caused by a chain or web consisting of many component causes. Therefore, especially in the initial stage of epidemiological study, we need more complex framework to indicate overall relationships among multiple causative factors.

2) Gene-environment interaction model/multiple causality

This figure is gene/environment interaction model. Some people carry genetic factors that confer susceptibility or resistance to a certain disease in a particular environment. Physicians are interested in to understand whether the disease can be prevented by reducing exposure to environmental risks.

3) Epidemiological triad/multiple causality

Next figure is the epidemiological triad. This model comprises a susceptible host, a disease agent, and an environmental context. These three components are interconnected to form a triangle, and the triangle can be expressed somewhat differently. When we apply this model to communicable disease, agent is microbe, especially a pathogenic bacterium.

In the case of injury, the agent is some physical energy.

4) Wheel of causation model/multiple causality

This figure shows the wheel of causation model (Mausner & Kramer, 1985). This model de-emphasizes the agent as the sole cause of disease. Instead, it emphasizes the interaction of physical. biological and social environments. It represents the overlapping nature of various environments. It also brings genetics into the mix.

Even if the final epidemiologic hypothesis that you adopted takes a simplified format such as A causes B, multiple causality models are always useful to reflect the meaning of your study in complex real world situation.

5. Correlation and causation

In the process of detection of causality, a noteworthy point is correlation.

In statistic, correlation refers to the degree to which two or more attributes or measurements show a tendency to vary together.

We can use two-dimensional scatter diagram to visualize correlation.

I will give you the following examples.

Case 1 shows the correlation between "A: the number of firefighters" and "B: scale of fire"

Case 2 shows the correlation between "A:ice cream sales" and "B: rate of drowning deaths"

Correlations are useful because they can indicate a predictive relationship. However, although correlation can suggest causation, it doesn't imply causation.

If we assume direct causation between A and B, the following expression is derived;

such as "A ---> B", and/or "A causes B" ?

More specifically,

For case 1, "A: the number of firefighters" causes "B: scale of fire".

For case 2, "A:ice cream sales" causes "B: rate of drowning deaths".

Well, are these expressions correct?

Actually, neither of these are correct. The correct relationship is as follows.

For case 1, "B: scale of Fire" causes "A: the number of firefighters" (this is reverse causation).

For case 2, The third factor C (the common -causal variable) causes both A and B. The third factor C is the increase of exposure to water-based activities during hot season.

From these lessons, we conclude that "Correlation does not always imply causation".

6. Bradford Hill criteria to indicate causality

In 1965 Austin Bradford Hill proposed a series of considerations to help assess evidence of causation,which have come to be commonly known as the "Bradford Hill criteria".

1) Strength: A small association does not mean that there is not a causal effect, though the larger the association, the more likely that it is causal.[35]
2) Consistency: Consistent findings observed by different persons in different places with different samples strengthens the likelihood of an effect.
3) Specificity: Causation is likely if a very specific population at a specific site and disease with no other likely explanation.
4) Temporality: The effect has to occur after the cause.
5) Biological gradient: Greater exposure should generally lead to greater incidence of the effect.
6) Plausibility: A plausible mechanism between cause and effect is helpful.
7) Coherence: Coherence between epidemiological and laboratory findings increases the likelihood of an effect.
8) Experiment: "Occasionally it is possible to appeal to experimental evidence".
9) Analogy: The effect of similar factors may be considered.

Hill's criteria are not exactly a checklist to be implemented for assessing causality. Hill's criteria should be used to scrutinize the meaning of observed relationship and elaborate the understanding of causality.

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