Validity and Reliability, Causality, Causal Relationship Possibilities, External Validity

This article discusses measures of association, causality relationship and different possibilities in a causal relationship. The Bradford Hill criteria comprising nine principles are also being discussed. The possibilities of a causal relationship include four principles. The article also explains reliability, validity, and related characteristics. The major threats to reliability discussed in the article include poor sampling, instability, and divergence.

Measures of Association

It refers to a wide variety of co-efficients which are required to measure the statistical strength of different variables. There are many statistical distinctions associated for the understanding of the association between statistical measures. The statistical measures are different from statistical significance. Measures of association assume a categorical or continuous level of data. Perfect predictive monotonicity, as well as perfect ordered monotonicity, is impossible to achieve at the same time in a measure of association.

The categorical data includes nominal or cordial data level, whereas the casual direction followed by the measure of association is based on symmetrical or asymmetrical direction. Measures of association can be categorized into four types, including;
concordant pairs, discordant pairs, tied pairs on one variable and tied pairs on the other variable.

Causality

Causality refers to any reason which leads to a specific disease in order to diagnose a disease timely and to take preventative or curative measures. A cause can be sufficient or necessary or both in order to create an effect leading to a specific disease. There can be more than one causal mechanism leading to a single disease.

The causality relationship refers to the association between cause and its effect on an individual. There are several factors in causality, such as:

- Predisposing factors,
- Enabling factors,
- Precipitating factors, and
- Reinforcing factors.

Bradford has defined criteria to define a cause and effect relationship.

Bradford Hill Criteria

Austin Bradford Hill in 1965 introduced certain criteria to provide evidence for the causal relationship between a presumed cause and an observed effect. This criterion is used in public health research processes. It is helpful in the epidemic research process by addressing different areas involved. There are nine principles of Bradford Hill criteria given as follows:

Temporality

It refers to the time relationship between cause and effect. Primarily, for a disease to occur, cause should precede effect thus exposure, disease, treatment and resolution should occur in that order. The effect which occurs due to a cause by the subject is addressed in the context of time under this principle. The delay in the cause and effect relationship is addressed under this category. It states that if there is a delay in effect related due to effect, it should have occurred after the delayed period.

Strength and association

It refers to the effect size created due to the epidemic cause. The size of an association impacts the intensity of effect. The cause and effect relationship is usually seen in the context of a statistical correlation between repeated events. The full strength correlation is denoted by 1. In case an association is weak, the cause and effect relationship will show higher variations and vice versa. It has been used to point out factors that increase the likelihood of a disease incidence with physicians using this principle to guide on healthy lifestyles.

Biological gradient (dose-response)

In case a patient is given a dose, there is a relationship between the dose of medicine and the reaction of the patient caused by the dose. It does not indicate a simple linear relationship due to a minimum and maximum thresholds. An association
can have a causal relationship if there is the existence of a biological gradient between exposure and disease. The higher the exposure, the greater the effect of the cause. In some circumstances, the mere presence of a biological gradient can trigger a large effect.

Consistency

In order to find out reproducibility for a research process, the consistency principle is mandatory to keep it going at a wider context. In order to prove the usefulness of treatment, the consistency principle contributes for making up its productivity in a wide range of circumstances; thus, the more a principle is established in numerous studies with different methodologies, the higher the chances of an effect being verified.

Plausibility

The cause and effect relationship should be sensible and logical in the context of all related theories, concepts and results. In case the causal relationship between the cause and effect of a subject indicate the occurrence of factors outside the science of research, it may create a hindrance in the accurate analysis of the causal relationship. It investigates the plausible mechanism employed by the causal relationship between cause and effect. The principle also advocates for allowing what is not yet known to be seen as possible if more research is put into it; thus, new information should not be dismissed or discarded without medicine and scientific tests.

Specificity

In case there is no other plausible explanation, it explains the specificity of a population. In case there is a specific population of patients suffering from asthma in a town in California, there will be a specific association between the disease factor and its effect.

The more specific this association will be, the bigger the probability of the existence of a causal relationship. It is not always possible in medical research that the symptoms of a disease are caused by a wide range of causing conditions. The fact that diseases have multiple etiologies, as well as therapies, weakens this criterion which is rectified with technological developments that allow isolation so as to measure specificity.

Evidence

The experimental evidence gives a strong proof for the cause and effect relationship between a disease and the factors causing it. Several significant variables are held stable in order to prevent them from interfering in the experimental results.

Analogy

This principle considers the effect of similar factors in order to create a logical relationship between the suspected cause and its effect. The other related factors should create a logical sense with the research subject; otherwise, they should be removed from the investigation process.

Coherence

The likelihood of the effect of a cause and its effect increases when there is coherence between epidemiological and laboratory findings of an experiment.
Despite the Coherence principle, Hill noted that in case the laboratory evidence is not available or insufficient, it cannot completely nullify the epidemiological effect on associations.

**Possibilities in a Causal Relationship**

There are four conditions of a causal relationship which should be fulfilled in order to create an association. These conditions include:

1. Necessary and sufficient
2. Necessary, but not sufficient
3. Sufficient, but not necessary
4. Neither sufficient or necessary

**Necessary and sufficient**

In case a **condition is necessary for the occurrence of a dependent condition** because, without it, there is no possibility of an occurrence of another condition. This condition should also be sufficient enough to cause and effect. In such a situation, both necessary and sufficiency requirements should be fulfilled.

**Example**: Corona Virus causes SARS disease; here, the necessary condition for SARS disease is the Corona virus.

![Diagram](image)

"Necessary and Sufficient" by Lecturio

**Necessary, but not sufficient**

This is the condition where the **existence of a situation is enough to cause a problem**. In this situation, it is not necessary to measure the sufficiency of the condition for the occurrence of the related effect.

**Example**: In case a gene is activated by an environmental trigger like pollution or other harmful factors, it can produce disease. In this case, it is not necessary that the trigger is sufficient, only its existence can cause the problem.
Sufficient, but not necessary

In this situation, the sufficiency of a factor is necessary to create an effect.

Example: Both radiation and benzene poisoning can lead to leukemia. In this situation, both leukemia and benzene alone are sufficient to cause leukemia, but none of them are necessary for the calamity.

Neither sufficient or necessary

In case none of the factors are mandatory for the occurrence of a condition.

Example: Being tall is neither necessary nor sufficient for a person to become educated in life.

In case of epidemics, the effect which is caused by any damaging factor requires no specific sufficient or necessary condition for the occurrence of the disease.
Validity and Reliability

Reliability

It refers to the **degree to which a method or tool is used to generate stable and consistent results**. It is how dependable and consistent a particular test can measure a given characteristic. It is indicated by a reliability coefficient. There are several types of reliability, such as:

- **Test-retest reliability**: A test is taken twice to measure reliable results. Repeatability is important to attain reliability.
- **Parallel forms reliability**: Different versions of assessment tools are used to generate desirable results. High-reliability coefficient indicates the tests will yield the same result regardless of which test is taken, while the low-reliability coefficient indicates that the tests are not similar thus they cannot be interchanged.
- **Inter-rater reliability**: Different raters are approached to find out the accurate results of research. Raters need to be well trained for these reliabilities to be stable.
- **Internal consistency reliability**: Measures the degree to which different test samples generate the same result. This reliability can be affected by the length of a test and the results effectively reveal homogeneous or the heterogeneous nature of sample items.

Validity

It refers to the **ability of a test measure to estimate a result which is desired to be measured**. Key points are the characteristics and how well they are measured to the extent that predictions can be made based on test scores. Reliability alone is not sufficient to evaluate the required results. **For ensured reliability, a test should be valid.** Validity tests can be based on a criterion, content, and the construct or characteristic. It is indicated by a validity coefficient.

**Example**: Suppose a weight scale is off by 5 lbs. On a daily weight measurement, the weight scale shows the weight in access of 5 lbs. Now the scale measures the weight reliably, but still, it does not give a valid result.

**Internal validity**

Internal validity **refers to zero generalizability concern**. It shows that the researcher...
has evidence that the measures taken to an investigation or research purpose have caused what has been observed in a study.

The major requirements of internal validity include **temporality, strength, and plausibility**. It revolves around the question of the application of scientific research methods in the experimental design.

Major threats include **confounding and selection bias**.

**External validity**

It is the **degree to which the results of a study can be generalized at a large extent or for the general population**. The findings of research and experiment are measured to be sufficient for a large population to conclude a specific or required result.

The requirements of external validity include minimized observer effects, and parsimonious exclusion criteria. It generally allows identifying of other causal relationships that may be applied to other possibilities.

There are several threats to be countered by external validity, including overly-specific study characteristics, The **Hawthorne effect (human beings tend to alter their behavior when being studied)**, and the **Rosenthal/Experimenter expectancy effect** (the researcher may develop a bias based on their expected outcome on their experiments). External validity further has two types, i.e., population validity and ecological validity.

**Population validity**

It refers to the extent to which the results of an experiment can be generalized to the whole population. In case the sample population well represents the reference population, it is known as the population validity.

**Ecological validity**

In this case, the environment of the study has a complete resemblance with the real world. It is the extent to which the conclusions of a research study match with the generalized findings in the context of the whole population.

Validity and reliability are the philosophical cornerstones of what is accepted as scientific proof.

**Threats to Reliability**

The major threats to reliability include:

**Environmental changes**

The time in between the measurement may experience environmental changes which affects measurements that are taken.

**Observer/researcher error**

It can occur during measurement reading and recording which would alter the reliability coefficient significantly.
Poor sampling

In case the sample selected does not represent the whole population, it can lead to inappropriate and unreliable results of a research or experiment.

**Example:** The mean age of a non-random sample represents an inappropriate population.

Instability

It refers to the inconsistent characteristics of a subject which is evaluated for the required results.

**Example:** Suppose blood pressure is measured multiple times a day, the blood pressure here is the instable variable which changes every time it is measured. It can lead to unreliable results.

Divergences

In case raters or evaluators have divergence in their moods, it can lead to untrusted results.

References


Norman Swartz, 1997. *Necessary Conditions and Sufficient Conditions.* Available at: https://www.sfu.ca/~swartz/conditions1.htm


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