# An Introduction to Evidence-based Problem Solving
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Evidence-based problem solving is an approach to problem solving which has be applied to a wide range of problems including health, education, and a wide range of social problems. The basic method can be displayed using the following graphic:

Evidence-Based Problem Solving

Evaluation → Problem → Etiology/Efficacy → Recommendations → Implementation → Evaluation
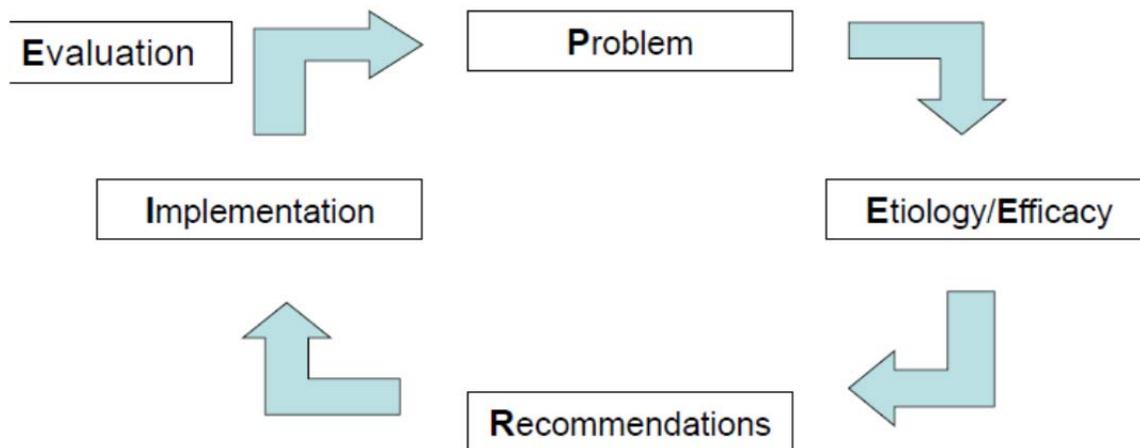
Note that evidence-based problem solving is displayed as a circular process since most of the complex problems we currently face are not solved by a single intervention or magic bullet. Even clearly effective interventions need to be evaluated to determine their degree of effectiveness and the extent and characteristics of the problem that remains.

Evidence-based problem solving is increasingly used to address problems ranging from health and disease to education to criminal behavior to economic development etc. In this exercise a health problem is used. The components of the evidence-based problem solving approach will therefore be discussed using the language of health and disease.

Problem

A health problem can be characterized by the burden it produces and the course of the disease or condition. The burden of disease is usually defined by its mortality and morbidity that is the rate of death and the rate of disability that results from the disease.

Mortality rates indicate the number of deaths relative to the population affected by a problem over a period of time usually one year. That is, mortality rates have a numerator which includes the number of deaths, a denominator which includes what is called the "population at risk", and a period of time. This measure may be complicated by the fact that death only occur once a birth has occurred. A stillbirth or fetal death after 20 weeks gestation is therefore not considered a birth so no death is recorded in the official statistics. Likewise the population at risk is not obvious. In conditions which occur early in life the denominator usually includes the number of live births.

The course of a disease if often described using three measures known as incidence, prevalence, and case-fatality. Incidence is the probability of developing the condition over a period of time usually one year. Incidence is also called risk since it measures the risk or chance of developing a condition. Incidence is a key measure for studying the cause or etiology of a disease or other condition. Comparing the incidence in different groups or in the same group in different years may generate hypotheses or ideas about the cause or etiology. Comparing populations rather than individuals is called a population comparison or ecological study.

Prevalence is the probability of having a disease or other condition at one particular point in time. The prevalence of a condition depends on the incidence rate and also the average duration of the disease that is, the average amount of time that individuals live with the disease. Prevalence is very useful for estimating the current impact of a problem or the burden of disease.

Case-fatality is a simple but important measure of the severity of the problem or its prognosis. Case-fatality measures the number of deaths relative to the number of individuals diagnosed with a condition. Prognosis may also be measured using measures short of death such as the probability of paralysis, or blindness, or a range of other undesirable outcomes.

Etiology and Efficacy

Etiology or cause and effect and efficacy or the impact of an intervention under research conditions are two closely related issues. By intervention we mean any approach that aims to improve outcome ranging from prevention, to early detection, to treatment, to palliation. Cause and effect or efficacy in health can be viewed as two sides of the same coin. Both of them require that the following criteria be fulfilled:

- *The "cause" is associated with the "effect".* That is the "cause" and the "effect" occur together more often than expected by chance alone (i.e. there is a statistically significant association).

Using intervention language the use of the intervention occurs together with an improved outcome more often than expected by chance alone.

- *The "cause" precedes the "effect"* That is the "cause" is present at an earlier time than the "effect". Using intervention language the use of the intervention precedes in time the improve outcome.
- *Altering the "cause" alters the "effect"* Changing or altering the "cause" in a study group results in a change in the probability of the "effect" in the study group but not in a similar control or comparison group. Here cause and effect and efficacy come together since an intervention is usually needed to establish this final criterion.

In health related research three types of investigations or studies are often used to establish these three criteria. These are called case-control studies, cohort studies, and randomized controlled trials. Case-control studies begin by identifying "cases" with the disease and similar "controls" without the disease. Case-control studies then look back in time to determine whether the cases and the control previously had the factor or risk factor under investigation. Case-control studies are very useful for establish that an association exists between the risk factor and the disease among individuals. They may attempt to establish which came first but are prone to what is called reverse causality that is, the early stages of the disease may actually bring about the increase in the risk factor.

Cohort studies or prospective studies start by identifying those with and those without a hypothesized risk factor. The investigator then looks to see what subsequently happens to those with and those without the risk factor. Cohort studies are useful for establishing that the "cause" precedes the "effect".

Cohort studies allow calculation of a relative risk or the probability that the disease will occur when the risk factor is present compared to when it is absent. Relative risk allows one to calculate the attributable risk percentage or the percentage of the disease which is associated with the risk factor. Attributable risk percentage can be calculated even when cause and effect has not been established. If a cause and effect relationship has been established and the impact of the "cause" is immediately and completely reversible, attributable risk percentage (or percent efficacy as it may be called) estimates the percentage of the disease among those with the risk factor which may be prevented by elimination of the risk factor.[1]

Randomized controlled trials when ethical and practical are the gold standard for establishing cause and effect or efficacy. They rely on randomization to ensure that the study group and the comparison or control groups are as similar as possible. Randomization implies that a chance process is used to assign or allocate individuals to two or more possible study and control groups. Randomized controlled trials can potentially establish all three criteria for efficacy but are generally used to establish the third criterion that is that altering the "cause" alters the "effect".

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[1] Case-control studies can produce an estimate of relative risk known as an odds ratio. Odds ratio can often be used to calculate an attributable risk percentage. The attribute risk percentage can be calculated as (relative risk - 1)/ relative risk x 100% when the relative risk is greater than 1. When the relative risk is less than one the attributable risk percentage is calculated as (1- relative risk) X100%.
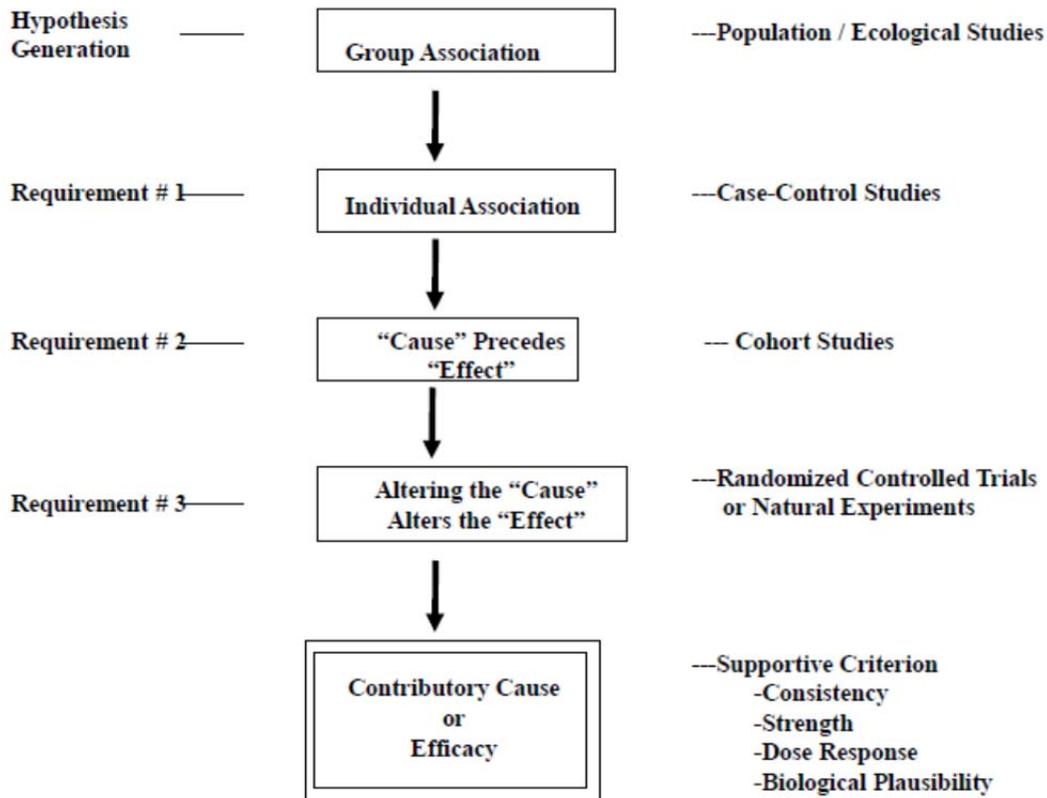
Randomized controlled trials may not be practical or ethical. When this is the situation additional supportive or ancillary criteria are often used to argue for or against cause and effect or efficacy. The most generally accepted of these criteria are:

- *Consistency-* a large number of studies in different setting produce similar results
- *Strength of the relationship-* very strong relationship such as a large relative risk of 10 is suggestive of cause and effect relationships since a large relative risk is unlikely to be the consequences of poor study design.
- *Dose-response relationships-* increased probability of disease with progressively increasing exposure to a risk factor or decreased probability of disease with progressively increasing exposure to a protective factor support efficacy or cause and effect. A dose-response relationship suggests that altering the "cause" alters the "effect".
- *Biological plausibility-* relationships that can be explained by known biological mechanisms strengthen the conclusion that a cause and effect relationship exists.

Cause and effect relationship may exist even in the absence of these criteria but their presence support scientific judgments that a cause and effect relationship or efficacy has been demonstrated

The next figure illustrates how these three types of investigations can be combined to establish the three criteria for cause and effect or efficacy.

Contributory Cause/ Efficacy

Hypothesis Generation ————	**Group Association**	---Population / Ecological Studies
Requirement # 1 ———	**Individual Association**	---Case-Control Studies
Requirement # 2 ———	**"Cause" Precedes "Effect"**	--- Cohort Studies
Requirement # 3 ———	**Altering the "Cause" Alters the "Effect"**	---Randomized Controlled Trials or Natural Experiments
	Contributory Cause or Efficacy	---Supportive Criterion -Consistency -Strength -Dose Response -Biological Plausibility

Evidence-based Recommendations

Recommendations for use of an intervention require consideration of safety as well as efficacy that is they require us to balance the benefits and the harms. Balancing the benefits and the harms requires us to examine the quality of the evidence as well as the magnitude or size of the potential impacts that is the benefits minus the harms.

When comparing benefits and harms, we need to place importance, value or utility on each of the potential benefits and potential harms that can occur. That is, we may need to compare outcomes such as paralysis, dementia, pain, and death. The relative importance of these different types of outcomes are likely to differ from person to person and lead to a great deal of the controversy when making recommendations for large populations.

Evidence-based recommendations may also take into account costs especially when the benefits only slightly outweigh the harms. When and how to incorporate costs into evidence-based recommendations remains highly controversial for health related issues.

Implementation of Interventions

After an evidence-based recommendation has been made declaring that the benefits or an intervention outweigh its harms, it is still necessary to consider the best method(s) for implementing the intervention. When examining the options for intervention it is helpful to consider "when", "who" and "how". These issues can be analyzed as follows:

- *When-* An intervention can occur before the disease has occurred i.e. primary intervention, before it produces symptoms i.e. secondary intervention or early detection, and after symptoms but before irreversible complications i.e. tertiary intervention. Each of these times for intervention have advantages and disadvantages and they may often be combined to produce an overall strategy for intervention.
- *Who-* An intervention may be aimed at one individual at a time as is commonly done in clinical settings. Alternatively groups of individuals with a risk factor or disease may be the focus for an intervention. Finally at time the entire population may be the focus of the intervention including both those with and without the risk factor. The advantages and disadvantages of these approaches require careful consideration when designing an intervention strategy.
- *How-* Interventions may be classified as those which require and those which do not require behavioral change. When behavioral change is required we can consider three basic approaches education or information, motivation or incentives, and obligation or legal requirements. Each of these approaches has advantages and disadvantages which need to be carefully considered when designing an intervention strategy.

Evaluation

The results on an intervention need to be evaluated to establish the impact of the intervention. When efficacy of an intervention has been definitely established its impact when put into practice may be evaluated based on what are called "before-and-after-studies". These investigations merely compare the rates of the disease or other condition in the same population before and after the introduction of the intervention. In before-and-after-studies population or groups in which the intervention has been used are often compared to populations or groups in which the intervention has not been used. Before-and-after-studies may be population comparisons and may not include information on individuals.

Evaluation methods are increasingly being used to better understand the continuing burden of disease as well as the situations in which the intervention's benefits outweigh its harms as well as the situations where the harms outweigh the benefits. These investigations often need to take into account the timing of the benefits and harms and the age or other demographic or social characteristics of those who experience the benefits and the harms. Finally to balance the benefits and the harms evaluation studies need to measure the value, importance, or utility that individuals or society at large places on each of the potential benefits and the potential harms.

Evaluation studies often lay the ground work for additional rounds of problem solving. They may measure the extent of remaining disease or suggest additional risk factors or additional interventions. Finally they may suggests ways that two or more problems are related as part of a system and thereby help identify bottlenecks which need to be circumvented to increase the impact of interventions or leverage point which can utilized to maximize the impact of interventions.