Causation vs. Correlation

One of the most common errors we find in the press is the confusion between *correlation* and *causation* in scientific and health-related studies. In theory, these are easy to distinguish — an action or occurrence can *cause* another (such as smoking causes lung cancer), or it can *correlate* with another (such as smoking is correlated with alcoholism). If one action causes another, then they are most certainly correlated. But just because two things occur together does not mean that one caused the other, even if it seems to make sense.

Unfortunately, our intuition can lead us astray when it comes to distinguishing between causality and correlation. For example, eating breakfast has long been correlated with success in school for elementary school children. It would be easy to conclude that eating breakfast *causes* students to be better learners. It turns out, however, that those who don't eat breakfast are also more likely to be absent or tardy — and it is absenteeism that is playing a significant role in their poor performance. When researchers retested the breakfast theory, they found that, independent of other factors, breakfast only helps undernourished children perform better.

Many many studies are actually designed to test a correlation, but are suggestive of "reasons" for the correlation. People learn of a study showing that "girls who watch soap operas are more likely to have eating disorders" — a correlation between soap opera watching and eating disorders — but then they incorrectly conclude that watching soap operas *gives* girls eating disorders.

In general, it is extremely difficult to establish causality between two correlated events or observances. In contrast, there are many statistical tools to establish a statistically significant correlation.

There are several reasons why common sense conclusions about cause and effect might be wrong. Correlated occurrences may be due to a common cause. For example, the fact that red hair is correlated with blue eyes stems from a common genetic specification which codes for both. A correlation may also be observed when there is causality behind it — for example, it is well-established that cigarette smoking not only correlates with lung cancer, but actually causes it. But in order to establish cause, we would have to rule out the possibility that smokers are more likely to live in urban areas, where there is more pollution — or any other possible explanation for the observed correlation.

In many cases, it seems obvious that one action causes another. However, there are also many cases when it is not so clear (except perhaps to the already-convinced observer). In the case of soap-opera watching anorexics, we can neither exclude nor embrace the hypothesis that the television is a cause of the problem — additional research would be needed to make a convincing argument for causality. Another hypothesis is that girls inclined to suffer poor body image are drawn to soap operas on television because it satisfies some need related to their poor body image. Yet another hypothesis is that neither causes the other, but rather there is a common trait — say, an overemphasis on appearance by the girls' parents — that causes both an interest in soap operas and an inclination to develop eating disorders. None of these hypotheses are tested in a study that simply asks who is watching soaps and who is developing eating disorders, and finding a correlation between the two.

How, then, does one ever establish causality? This is one of the most daunting challenges of public health professionals and pharmaceutical companies. The most effective way of doing this is through a *controlled study*. In a controlled study, two groups of people who are comparable in almost every way are given two different sets of experiences (such one group watching soap operas and the other game shows), and the outcome is compared. If the two groups have substantially different outcomes, then the different experiences may have caused the different outcome.

There are obvious ethical limits of controlled studies – it would be problematic to take two comparable groups and make one smoke while denying cigarettes to the other in order to see if cigarette smoking really causes lung cancer. This is why epidemiological (or observational) studies are so important. These are studies in which large groups of people are followed over time, and their behavior and outcome is also observed. In these studies, it is extremely difficult (though sometimes still possible) to tease out cause and effect, versus a mere correlation.

Typically, one can only establish correlation unless the effects are extremely notable *and* there is no reasonable explanation that challenges causality. This is the case with cigarette smoking, for example. At the time that scientists, industry trade groups, activists and individuals were debating whether the observed correlation between heavy cigarette smoking and lung cancer was causal or not, many other hypotheses were considered (such as sleep deprivation or excessive drinking) and each one dismissed as insufficiently describing the data. It is now a widespread belief among scientists and health professionals that smoking does indeed *cause* lung cancer.

When the stakes are high, people are much more likely to jump to causal conclusions. This seems to be doubly true when it comes to public suspicion about chemicals and environmental pollution. There has been a lot of publicity over the purported relationship between autism and vaccinations, for example. As vaccination rates went up across the United States, so did autism. However, this correlation (which has led many to conclude that vaccination causes autism) has been widely dismissed by public health experts. The rise in autism rates is likely to do with increased awareness and diagnosis, or one of many other possible factors that have changed over the past 50 years.

In general, we should all be wary of our own bias; we like explanations. The media often concludes a causal relationship among correlated observances when causality was not even considered by the study itself. Without clear reasons to accept causality, we should only accept correlation. Two events occurring in close proximity does not imply that one caused the other, even if it seems to makes perfect sense.