

## Causation and Observational Studies

**CO-3:** Describe the strengths and limitations of designed experiments and observational studies.

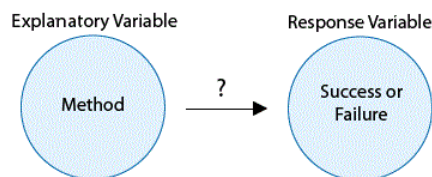
### Learning Objectives

**LO 3.2:** Explain how the study design impacts the types of conclusions that can be drawn.

### Video

**Video:** [Causation and Observational Studies](#) (3:09)

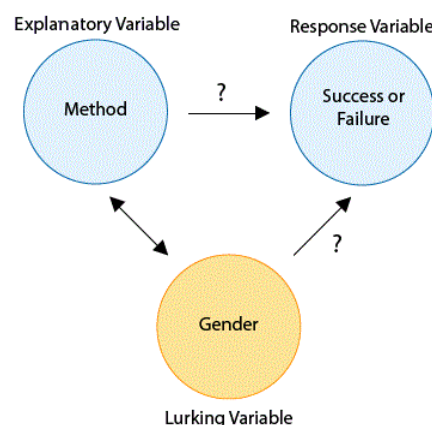
Suppose the **observational study** described earlier was carried out, and researchers determined that the percentage succeeding with the combination drug/therapy method was highest, while the percentage succeeding with neither therapy nor drugs was lowest. In other words, suppose there is clear evidence of an association between method used and success rate. Could they then conclude that the combination drug/therapy method causes success more than using neither therapy nor a drug?



It is at precisely this point that we confront the underlying weakness of most observational studies: some members of the sample have opted for certain values of the explanatory variable (method of quitting), while others have opted for other values. It could be that those individuals may be different in additional ways that would also play a role in the response of interest.

For instance, suppose women are more likely to choose certain methods to quit, and suppose women in general tend to quit more successfully than men. The data would make it appear that the method itself was responsible for success, whereas in truth it may just be that being female is the reason for success.

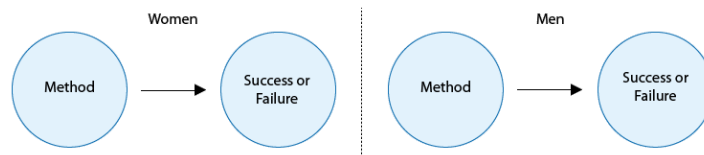
We can express this scenario in terms of the key variables involved. In addition to the explanatory variable (method) and the response variable (success or failure), a third, **lurking** variable (gender) is tied in (or **confounded**) with the explanatory variable's values, and may itself cause the response to be a success or failure. The following diagram illustrates this situation.



Since the difficulty arises because of the lurking variable's values being tied in with those of the explanatory variable, one way to attempt to unravel the true nature of the relationship between explanatory and response variables is to separate out the effects of the lurking variable. In general, we **control** for the effects of a lurking variable by separately studying groups that are defined by this variable.

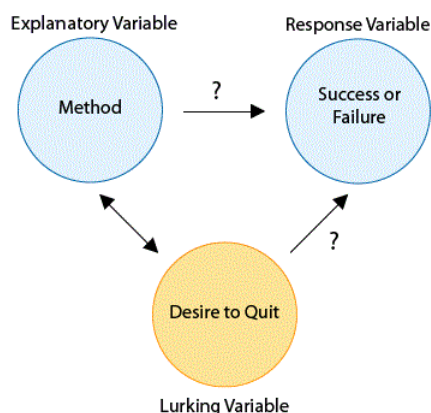
**Caution**

We could control for the lurking variable “gender” by **studying women and men separately**. Then, if both women and men who chose one method have higher success rates than those opting for another method, we would be closer to producing evidence of causation.



The diagram above demonstrates how straightforward it is to control for the lurking variable gender.

Notice that we did not claim that controlling for gender would allow us to make a definite claim of causation, only that we would be closer to establishing a causal connection. This is due to the fact that other lurking variables may also be involved, such as the level of the participants’ desire to quit. Specifically, those who have chosen to use the drug/therapy method may already be the ones who are most determined to succeed, while those who have chosen to quit without investing in drugs or therapy may, from the outset, be less committed to quitting. The following diagram illustrates this scenario.



To attempt to control for this lurking variable, we could interview the individuals at the outset in order to rate their desire to quit on a scale of 1 (weakest) to 5 (strongest), and study the relationship between method and success separately for each of the five groups. But desire to quit is obviously a very subjective thing, difficult to assign a specific number to. Realistically, we may be unable to effectively control for the lurking variable “desire to quit.”

Furthermore, who’s to say that gender and/or desire to quit are the only lurking variables involved? There may be other subtle differences among individuals who choose one of the four various methods that researchers fail to imagine as they attempt to control for possible lurking variables.

For example, smokers who opt to quit using neither therapy nor drugs may tend to be in a lower income bracket than those who opt for (and can afford) drugs and/or therapy. Perhaps smokers in a lower income bracket also tend to be less successful in quitting because more of their family members and co-workers smoke. Thus, socioeconomic status is yet another possible lurking variable in the relationship between cessation method and success rate.

It is because of the existence of a virtually unlimited number of potential lurking variables that we can never be 100% certain of a claim of causation based on an observational study. On the other hand, observational studies are an extremely common tool used by researchers to attempt to draw conclusions about causal connections.

If great care is taken to control for the most likely lurking variables (and to avoid other pitfalls which we will discuss presently), and if common sense indicates that there is good reason for one variable to cause changes in the other, then researchers may assert that an observational study provides good evidence of causation.

Observational studies are subject to other pitfalls besides lurking variables, arising from various aspects of the design for evaluating the explanatory and response values. The next pair of examples illustrates some other difficulties that may arise.

## ✓ EXAMPLE:

Suppose researchers want to determine if people tend to snack more while they watch TV. One possible design that we considered was to recruit participants for an observational study, and give them journals to record their hourly activities the following day, including TV watched and snacks consumed. Then they could review the journals to determine if snack consumption was higher during TV times.

We identified this as a prospective observational study, carried forward in time. Studying people in the more natural setting of their own homes makes the study more realistic than a contrived experimental setting. Still, when people are obliged to record their behavior as it occurs, they may be too self-conscious to act naturally. They may want to avoid embarrassment and so they may cut back on their TV viewing, or their snack consumption, or the combination of the two.

Yet another possible design is to recruit participants for a retrospective observational study. Ask them to recall, for each hour of the previous day, whether they were watching TV, and what snacks they consumed each hour. Determine if food consumption was higher during the TV times.

This design has the advantage of not disturbing people's natural behavior in terms of TV viewing or snacking. It has the disadvantage of relying on people's memories to record those variables' values from the day before. But one day is a relatively short period of time to remember such details, and as long as people are willing to be honest, the results of this study could be fairly reliable. The issue of eliciting honest responses will be addressed in our discussion of sample surveys.

By now you should have an idea of how **difficult — or perhaps even impossible** — it is **to establish causation in an observational study**, especially due to the problem of lurking variables.

The key to establishing causation is to rule out the possibility of any lurking variable, or in other words, to ensure that individuals differ **only with respect to the values of the explanatory variable**.

In general, this is a goal which we have a much better chance of accomplishing by carrying out a well-designed experiment.

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