This tutorial talks about establishing causality. Causality refers to the existence of a cause and effect relationship. So, for example, if we're talking about smoking and cancer, if we are trying to determine whether or not there was a cause and effect relationship between smoking and cancer, we would be determining whether or not causality exists.

In order to do this, once we suspect that there is causality, one thing we might do is look for cases when the correlation remains, while other factors vary. So, for example, while we vary the age or the gender or the race of different people, we will look to see whether or not that correlation between smoking and cancer exists.

If the people who smoke end up having cancer, we'd be finding out that correlation, and that can help us determine the causality. If it remains while the other factors vary-- so if we find out that yes, smoking tends to link with cancer across all different age groups-- that would start to hint that yes, there might be this cause and effect relationship. That there might be causality there.

We would also want to check to see if the effect is present or absent when the explanatory variable is present or absent. For example, if when someone smokes then yes, we see lung and mouth cancer versus when someone doesn't smoke, we do not see lung and mouth cancer that would also be a good hint that there perhaps is that causal relationship.

Now with this, we would also need to look for evidence that larger amounts of the suspected cause produce a larger effect. For example, with smoking, if people who smoke for longer or smoke more packs a day have a greater likelihood of having cancer, then that would also help us to establish causality.

We'd also want to look for other possible causes. What are the other reasons that those people might be getting cancer? Trying to eliminate other confounding variables.

Another way we can help to establish causality is by trying to determine the physical mechanism for cause and effect. How is it exactly that smoking causes cancer? What's the physical reason for this happening?

And then finally, another way to establish causality is to do a randomized trial. For example, with rats. If we had a population of rats that we gave cigarettes or nicotine or whatever part of smoking is that we think causes cancer to one group and then to the other randomly selected group we did not, if the

rats that we randomly gave the smoking treatment to developed cancer, then that would help us to establish that cause and effect relationship between smoking and cancer.

Within this establishment of causality, there are different levels of confidence. We can have possible cause, probable cause, and cause beyond a reasonable doubt. This sounds very familiar to terms you might have heard in a TV courtroom drama or things like that.

Possible cause is just saying like the title would suggest, that there's possibly a relationship between smoking and cancer. Probable cause is saying that there is probably a relationship between smoking and cancer. And cause beyond a reasonable doubt is saying that we are almost, almost, almost positive that there is a cause and effect relationship. So beyond all of our reasonable doubts, any that we could possibly imagine, we think that one causes the other.

So depending on how many of those checks for causality we can pass through can help us to determine which level of confidence in causality we are at. And over time, that can change, too, just as our level of confidence in smoking causing cancer has changed over time.

This has been your tutorial on establishing causality.