

Random and Systematic Errors

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WHAT'S COVERED

This tutorial will compare random errors vs. systematic errors. Our discussion breaks down as follows:

1. Random Errors

2. Systematic Errors

1. Random Errors

Random errors are exactly that: *random*. They can simply occur through no fault of the person taking the sample. When a sample is taken from a larger population, the results are unknown, meaning that it's unclear if the results will accurately represent exactly what the population looks like.

IN CONTEXT

Suppose there were 100 individuals, which we will consider the population. Twenty of them were college students. You select 5 people out of the overall 100 for a sample. What would you expect to happen?

You would expect that twenty percent of the population are college students, which is one out of every 5 people. So you would probably expect one individual within your sample of 5 people to be a college student.

However, that doesn't always happen. You might not get any college students, or all five of them may be college students. Just because you expect to get one doesn't mean that will actually happen. Why not?

Let's say that the individuals with numbers 1 - 20 are the college students. Numbers 21 - 100 are individuals not in college. Using a random number generator, you might get a simple random sample that looks like this:

Sample	Percentage
85, 27, 17 , 94, 74	1 of 5, or 20%

One out of five of those is a college student, which is 20%.

Another simple random sample might look like this:

Sample	Percentage
72, 92, 45, <mark>20</mark> , 38	1 of 5, or 20%

Again, one out of five is a college student.

However, you might get a simple random sample that looks like this:

Sample	Percentage
46, <mark>5</mark> , 83, 26, <mark>20</mark>	2 of 5, or 40%

Here, the second person, number 5, and the fifth person, number 20, are college students, out of 100 individuals in the population. That's 40%. What went wrong? Nothing went wrong--it's just that random errors happen sometimes.

Random error occurs when the sample, just by chance, doesn't match up perfectly with the population. Random error is not a mistake that is correctable; it is simply something that happens when sampling randomly. While it can't be corrected or avoided completely, the impact can be minimized by increasing the sample size or by taking multiple samples of equal size. The larger the group, the better the chances are that a representative group will be obtained.

⇔ EXAMPLE Recall the example from above. Suppose that ten individuals from the group of 100 were chosen instead of five. Two college students would be expected to make it into the sample. So, if the sample was off by one, it reduces the impact since at least one college student would be represented.

TERM TO KNOW

Random Error

When the resulting value obtained from the sample does not match the value from the population simply by chance. This is not a mistake, but is inherent in the variability in sampling.

2. Systematic Errors

Now, by contrast, systematic errors are mistakes. Systematic errors are due to flaws in the design.

IN CONTEXT

Suppose a school board wants to estimate how many students are eligible for free or reduced lunch. If you have an under-coverage bias, or **selection bias**, your sample may include people from a poorer neighborhood that didn't respond to a questionnaire that was sent out. Perhaps their parents were working nights and didn't have time to complete the survey.

Therefore, the board may underestimate the true number of students requiring free and reduced lunch. This type of error cannot be remedied by increasing the sample size.

⇐ EXAMPLE A child has a growth chart in his room and his parents mistakenly put it up above the baseboard--an extra 2 inches from the floor. This is going to result in the child thinking he's 2 inches shorter than he actually is, an example of measurement bias, which is systematically wrong.

TERMS TO KNOW

Systematic Error

When the resulting value obtained from the sample does not match the value from the population as a result of an incorrect measurement or bias. This is a mistake made by the researcher.

Selection Bias

A bias that occurs when certain groups are systematically left out of the sample. This is a systematic error.

Measurement Bias

A mistake in the measurements taken in the study. This is a systematic error.

SUMMARY

Random errors occur when the sample selected doesn't match up with the population. It cannot be controlled, but using a larger sample will lessen the effect. Conversely, systematic errors result in wrong answers or wrong values in your sample, due to some kind of bias or error with your measurement. Increasing the sample size will not fix the issue. When a systematic error occurs, you might as well just start over, because there's no rescuing poorly collected data!

Good luck!

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Systematic Error

When the resulting value obtained from the sample does not match the value from the population as a result of an incorrect measurement or bias. This is a mistake made by the researcher.