# Module 9

## Quantitative Research Methods: Variables and Measurement

## Quadrant 1

### 1. Introduction

A variable is a characteristic, or a quantity of a phenomenon that can be measured or classified. As the name suggests, the values of variables can vary over time or across units. Quantitative research focuses on explaining the relationship between variables. Therefore, understanding the purpose, operationalization and measurement of variables is a key part of quantitative research.

### 2. Learning Outcomes

By the end of this module, a student will be able to:

- Understand what are variables and the different types of variables
- Understand the operationalization and measurement of variables
- Understand the scales of variable measurement

### 3. What are Variables?

As we have learned in previous modules, variables are an essential part of quantitative research. Variables are characteristics, or a quantity of a phenomenon that is the focus of a research project. Variables can be measured or categorized, and their values vary across unit, or across time. Gender, hair color, shoe size, income levels, disease status – all of these are examples of variables. However, variables can also measure abstract concepts – for example, self-esteem, well-being, sense of religiosity, intelligence, etc. Some variables are more complex, and may be studied through different dimensions of a particular item or phenomenon. For example, in a study on socioeconomic status we may use "income" as our variable or we may use ownership of a permanent housing structure or amount of savings. Another example is a study on academic achievement of 5$^{th}$ graders. Here, we could use "annual exam grade" as the variable denoting academic achievement or "average test grade" (the average of all exams and tests conducted during the year) or "literacy level" to denote academic achievement. Thus, different researchers studying the same topic may choose different variables, depending on the focus of their research. Different researchers may also use different ways of measuring the same concept.

A variable by definition must vary, that is the different participants or units in the study must demonstrate differences in terms of that variable. Gender may be a variable in one study and, therefore, in this study, you would expect to see people of different genders. But if a study was looking only at married women, then all people in the study would be women and so, gender of the woman would not be a variable in that study.

Quantitative research places great emphasis on variables because the main goal of quantitative research is to examine the relationship between two or more variables. Therefore, once the researcher identifies a research topic, the next step is to identify the key variables in the study. The best way to do this is to read studies that are similar to your chosen study. Once you analyze the different types of variables identified by other researchers, you will have a better idea of what variables might work best in your project.

Identifying the most appropriate variables is important for multiple reasons:

- Variables provide focus to the study. So if you pick the wrong ones, the findings of the study may go in a direction that was not expected by you.
- It is also important to focus on the methods and tools for measuring the selected variables. Picking the wrong ones may also take the findings into an unintended direction.
- Variables are also useful when you are searching for other studies (for example in journal articles) that are similar to yours. Thus, the variables can serve as search terms.

Researchers may also find it useful to pretest their choice of variables to make sure they provide the expected results.

In summary, during your literature review, spend some time analyzing the different types of variables used in the various studies relating to your topic, and how these choices affected the findings of the study. This process will give you some ideas of different variables you could use for your study, and will help you make the most informed choice.

## 4. Types of Variables

We use two types of variables in research studies, and you have learned about these in a previous module. The two types of variables are Independent and Dependent variables. Independent variables are variables that influence or predict change on Dependent variables. In conducting research studies, researchers observe how the Dependent variables change as the Independent variable changes. In an experimental study, the researcher controls or manipulates the Independent variable to see how this affects (or not) changes in the dependent variable(s). In a study which looks at causal effects, the Independent variable is a presumed cause whereas the dependent variable is the presumed effect. For instance, in a study which involves a new blood pressure medication, the new medication or the old medication would be the Independent variable while the differences in blood pressure before and after receiving medication would be the Dependent variable.

Social work research, however, usually examines research where it is difficult to pinpoint specific causes. It involves research where many things influence a phenomenon. For instance, academic achievement of tribal girls may be influenced by the teacher's attention, encouragement given by parents to education, whether the child has access to additional tutoring as well as whether a school has a toilet or not. Here we may think of the Dependent variable as something that we are interested in rectifying by altering the Independent variables through our interventions. It is more appropriate to say that the changes in the Independent variable predict changes in the Dependent variable.

## 5. Measurement of Variables

As we learned in Section #3, variables can measure simple phenomena directly (for example, hair color, age, income, etc.) or more complex concepts that may require a more indirect measurement (for example, socioeconomic status, academic achievement, etc.). When a study involves complex phenomena, researchers usually identify variables that measure only one or two dimensions of a complex concept. For example, if a study involves socioeconomic status, a researcher may pick "income" as the variable, while another researcher may pick "social class" as an indicator. Yet, socioeconomic status can actually mean not only these two elements, but could also refer to education status, and other similar elements. Therefore, researchers need to be careful in identifying variables to stand in for complex phenomena.

Keeping this in mind, the identification and measurement of variables involve two necessary elements we need to remember:

- Variables have *conceptual definitions* that essentially explain what the variable is attempting to capture.
- Variables also have an *operational definition* that define how the variable will be measured in the context of the study.

Let us look at our earlier example of socioeconomic status to understand this better.When we talk of socioeconomic status, we may be referring to a number of different aspects such as income, educational levels, class, occupational prestige, etc. This is the *conceptual definition*. However, in the context of a research study, a researcher only wants to focus on income levels of the sample. Thus, she uses "income" to be the *operational definition* of socioeconomic status within the context of her study.In the same way, since there is no direct way to measure "intelligence" which relates to both the capacity of an animal to acquire information or knowledge as well as to apply that acquired knowledge and information to solve problems or reach their goals. Researchers who are interested in exploring this concept in a study will need to identify a variable for doing so. Therefore, a researcher may choose to use "IQ test score" to operationalize the concept of "intelligence." They may even specify what type of IQ test to use.

Researchers therefore need to be very clear about both definitions of the variable. The conceptual definition is important because a researcher needs to understand all the complexities of a certain concept or construct. The operational definition is important because if this is inaccurate, it may lead to the identification of an inappropriate/incorrect variable, which can negatively influence the study and study results.However, remember that especially for complex variables, measurement may always be incomplete or inaccurate because you may not be able to find a variable that captures all aspects of a concept completely. Therefore, your goal should be to select the best possible variables to describe the concept. As suggested earlier, a good way to make sure you select the most appropriate variables is to review studies similar to yours, and check if the variables used would be appropriate or applicable to your study. If it is not possible to find appropriate variables in the literature, you may want to conduct some pretests to make sure the measures you have selected are appropriate. You could also use different measures of a concept to check how the results differ. For example, instead of using only "income levels' to operationalize the concept of socioeconomic status, you could also use "educational levels" or "ownership of different assets" in a single study to see how these multiple measures influence your findings.

When researchers want to check on the accuracy of their operational definition, they perform tests of "validity" and "reliability." "Validity" refers to the extent to which a measurement process truly measures the variable that it claims to measure. For example, we could ask to what extent income levels truly measure socioeconomic status. For instance, consider the hypothetical case of a land-owning family whose land and animals produce just enough during a year of poor rainfall to feed a large joint family but not enough to sell in the open market. Such a family would show a low family income but could not be compared to other families without land who have a similar family income. Our land-owning family still has assets such as land or cattle to sell off in case they face a problem which other families do not. So income level may be a poor indicator of socio-economic status and, in this situation, this particular way of operationally defining the phenomenon is not every effective.

"Reliability" refers to the extent to which repeated measurements under the same conditions produce the same or similar results. Thus, if measurement of IQ levels in several different contexts, but within the same conditions, provides us with similar results, we would conclude that IQ level is a reliable measure of intelligence. Validity and Reliability are partially related to some extent. A measurement cannot be reliable if it is not valid. For example, if the measurement of IQ level (as a measure of intelligence) shows significant variances in repeated measurements (which is the test of reliability), we would question its validity as a measure of intelligence. However, the reverse does not hold true – a measurement does not have to be valid to be reliable. For example, height cannot be considered a valid

measure for intelligence because does not appear to have a direct connection with intelligence. However, repeated studies show that height is correlated with intelligence. Thus, height is a reliable measure of intelligence, even though it is not a valid measure.

There are several elements to checking on reliability and validity of variables, and these factors need to be taken into account while using variables in your study. You will learn more about the concepts of Validity and Reliability in Module 10.

## 6. Scales of Measurement of Variables

Now that we have understood the issues involved with measuring variables, we can proceed to understand the different levels of variable measurement. Researchers must be clear about these levels of measurement because this determines the kind of statistical analysis that can be conducted. This in turn can influence the conclusions of the study especially when we attempt to describe the relationships between variables in the study.Variables are measured at four levels.

*6.1.* **Nominal variables**: Nominal variables are the most basic level of measurement. These are variables that have two or more mutually exclusive and exhaustive categories. However, these categories cannot be ordered. An example of this type of variable would be the states of India. Thus, Himachal Pradesh, Uttaranchal, Maharashtra are all states of India, but they do not have an intrinsic ranking order. You would have to apply some rule in order to rank them (for example, ranking by alphabetical order or in terms of land area or in terms of infant mortality or in terms of number of seats in parliament) – there are no inherent ranks to the states. Similarly, "gender" is also a nominal variable – male/female/ third gender are the three categories within this variable, but they cannot be ranked – they can only be compared.

*6.2.* **Ordinal variables:** Ordinal variables are also variables that have two or more categories, but they are different from nominal variables because they **<u>can</u>** be ranked, and ranks are used to determine the differences between the categories. However, while we can rank them, they do not carry a numerical value. They can only measure how one value is greater or lesser than another value. An example may be asking someone how often he or she watch movies on television – their response options are Very often, Frequently, Sometimes or Never. From his or her responses, we will know that someone who responds "frequently" watches movie more often than someone who responds "sometimes." However, none of these responses has a numerical value, so we cannot assess what is the numerical distance between "frequently" and "sometimes." Another example would be if we were to ask someone if they approve of the Right to Education Act. They may respond "Yes," "No," "Very much in agreement with it," or "Completely disagree with it." These response options form the different categories of the variable "Opinion on Right to Education Act" which is an ordinal variable.

*6.3.* **Interval variables:** Interval variables are variables that have a numerical value, and are measured on a continuum. They have an equal interval between items/values. They also have a numerical value. The most common example of this type of variable is the temperature when measured in Celsius or Fahrenheit. We know that temperature is measured on a continuum on thermometer. Therefore, we know that the difference between 10 to 20 degrees Celsius is the same interval value (10 degrees) as 30 to 40 degrees Celsius. Test scores on an IQ test is another example of an interval variable.

*6.4.* **Ratio variables**: Ratio variables are also measured on a continuum and have a numerical value. The difference between ratio variables and interval variables is that in ratio variables, there is an "absolute zero". Zero on the measurement scale indicates that there is no value of that variable or that the property being measured is completely absent at the zero level. Thus, we cannot say

temperature in Celsius or Fahrenheit are Ratio variables, because 0 (zero) degrees on both these scales does NOT mean there is no temperature. In fact, zero degrees Celsius actually indicates the freezing point on the Celsius scale. However, for those of you familiar with the Kelvin scale of measuring temperature, zero Kelvin does actually indicate there is no temperature, and therefore the Kelvin scale can be regarded as a Ratio variable. Other examples of ratio variables include height, weight, currency, mass, etc. The term "ratio", (which means a comparison of two quantities) implies that you can use the ratio of measurements.

Nominal and Ordinal variables are often referred to as Categorical variables or Qualitative variables since they contain two or more categories. Interval and Ratio variables are known as Continuous or Quantitative variables because they numerical values. A research study often includes different combinations of these variables. For example, if your study looks at school dropout-ism, you may collect nominal variables (names of the districts where the study is being conducted; gender of school dropouts), interval variables (grades of children who dropped out – A= 90-100 marks, B=80-89 marks, etc) and ratio variables (percentage of children who dropped out in each class).

In conclusion, variables are important because they help to measure concepts in a study. Because quantitative studies focus on measuring and explaining variables, choosing the right variables is important. The first step is to identify the correct variables to measure a property. Equally important is the conceptual definition, which explains how a variable will be defined and measured within the context of a particular study. Variables are measured on different scales, where at one end they can only be categorized or ranked, and at the other end they can be analyzed statistically.

## 7. A Note on Variables in Qualitative Research

We began this unit by saying that variables are integral to Quantitative Research because a researcher wants to assess or measure the impact of change in one or more variable on another variable. But qualitative research also sometimes uses the language of quantitative research. It will also refer to variables, namely characteristics on which people or social units differ. But here the researcher will not use statistical tests. Instead, they will build a conceptual map that shows the relationship between variables as initially hypothesized by them or as emerges from the revelations of research participants.

## 8. Summary

- A variable is a characteristic or a quantity of a phenomenon that can be measured or classified. The values of variables can change over time or across units.
- Variables are important to quantitative research because this type of research focuses on explaining the relationship between variables.
- Variables play a key role in the selection of the methods and tools in a study, and thus influence the results of the study.
- When choosing variables, the best way is to conduct a literature review, and see what variables have been used in similar studies. Where this is not a possibility, researchers may find it useful to pretest their choice of variables to make sure they provide the expected results. It is also advisable to use multiple variables to measure the same concept – this helps the researchers to identify which variables are the most appropriate fit, and can also help to ensure that the concept being measured is measured completely.
- Variables are of two types – Independent and Dependent variables.
- To check on the accuracy of their variables, researchers test the reliability and validity of their variables.
- Scales of measurement of variables are nominal, ordinal, interval and ratio.