

Quantitative Research: A Discussion on its Types, Challenges and Criticisms

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Abstract

This study discusses the components of quantitative research methodology in a systematic and logical order. Having observe that this type of research is highly structured, and the results are determined numerically or statistically to conduct natural and social science researches. Researchers prefer quantitative research for its creative characteristics and strengths. Findings of the study revealed that quantitative research methodology is founded on the scientific method. It uses experimental and observed measurements to develop theories and advance knowledge in the research area. The study also revealed that in this type of research the variables are clearly defined and results seem very accurate, as the results are obtained by mathematical formulae and statistical analyses. The paper concludes that researcher must be more conscious during data collection and interpretation to avoid bias in quantitative research.

Keywords: Correlational, Experimentation, Quantitative Research, Observational.

Introduction

Research is a systematic and organized effort to investigate a specific problem to provide a solution. The aim is to add new knowledge, develop theories as well as gathering evidence to prove generalisations (Sekaran, 2000). Research can be classified into three basic categories as: (1) quantitative research, (2) qualitative research, and (3) mixed method research (Swanson & Holton, 2005; Kothari, 2008; Creswell, 2011). Each of these methods plays important roles in research area. Researchers choose any one of the above three types of research methods according to the research aim, the objectives, the nature of the topic and the research questions to identify, collect and analyse information (Goertz & Mahoney, 2012). Quantitative research is formal, objective, rigorous, deductive approach, and systematic strategies for generating and refining knowledge to problem solving (Burns & Grove, 2005). Its designs are either experimental or non-experimental and seek to obtain accurate and reliable measurements (Rahman, 2017). It consists of systematic observation and description of the characteristics or properties of objects or events for the purpose of discovering relationships between an

independent (predictor) variable and a dependent (outcome) variable within a population (Best, 1981). The word “quantitative” means quantity or amount of information collected in the course of the study and is in a quantified or numeric form, i.e., in statistical supports, often using software, such as Excel, Access, SPSS, Python, SAS, JMP, R or Stata (White & Millar, 2014). Quantitative research explains phenomena by collecting numerical unchanging detailed data that are analyzed using mathematical based methods, in particular statistics that pose questions of who, what, when, where, how much, how many, and how. It deals in numbers, logic, and an objective stance. It is an original research in which the researcher decides what to study, asks specific, narrow question, collects quantifiable data from participants, analyse these numbers using statistics, and conducts the inquiry in an unbiased, objective manner (Creswell, 2011).

It considers interpersonal relationships, personal values, meanings, beliefs, thoughts, and feelings with human beings. It manipulates variables and control natural phenomena (Rarner, 1989). Quantitative research appeared around 1250 AD, and was driven by investigators with the need to quantify data. (Chen, 2011). This method was originally developed in the natural sciences to study natural phenomena (Williams, 2007). In quantitative research, a variable is a factor that can be controlled or changed in an experiment (Wong, 2014). It deals with quantifying and analyzing variables in order to get results. It is strictly positivistic, objective, scientific, and experimental. It should be used when, a highly structured research design is needed and can be naturally imposed on the experiment being conducted, the researcher needs to be totally objective; is not part of what he/she observes, and does not bring his/her own interests, values, or biases to the research, and although the phenomena being captured may be complex, they can be broken down and assigned some type of numerical value (Chen, 2011). Quantitative research methods deal with numbers and anything those are measurable in a systematic way of investigation of phenomena and their relationships. It is used to answer questions on relationships within measurable variables with an intention to explain, predict and control a phenomenon (Leedy, 1993).

In quantitative research researchers decide what to study, asks specific and narrow questions, collects quantifiable data from participants, analyses these numbers using statistics, and conducts the inquiry in an unbiased and objective manner. At present two-thirds research articles are published by the use of quantitative data, which are highly valid and provide high level of research quality (Given, 2008). The analysis of information from large samples almost inevitably requires quantitative methods (Hunter & Leahey, 2008).

In quantitative research statistical, mathematical or computational techniques are applied to obtain the accurate results. Recently this type of research is widely used in business studies, natural sciences, mathematical sciences and social sciences. The quantitative research data are collected through closed-ended questionnaires. The type of data is in numerical form, such as statistics, percentages, graphs, etc. The data are used to develop and employ models based on

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the form of mathematical models, theories, and hypotheses to obtain the desired result. A research hypothesis is an empirically testable statement that is generated from a proposition, which is clearly stated relation between independent and dependent variables (Given, 2008). The objective of quantitative research is to develop and use mathematical models, theories and hypotheses/propositions pertaining to phenomena (Given, 2008).

Objective of the Study

The main aim of this study is to represent the quantitative research methodology in natural and social sciences. The other specific objectives are as follows:

- i. To provide a historical background of the quantitative research.
- ii. To discuss steps, research design, and types of quantitative research.
- iii. To highlight characteristics, strengths and weaknesses, advantages and disadvantages of quantitative research.

Types of Research

Research can be classified into two categories as: (i) experimental, and (ii) non-experimental research (Cohen et al., 2000; Leedy & Ormrod, 2001; Borbasi & Jackson 2012).

(i) Experimental Research: Experimental research is the most familiar type of research design for individuals in the physical sciences and some other related fields. It tries to reduce all kinds of biases as much as possible (Nunan, 1992). It indicates how the observations or measurements should be obtained to answer a query in a valid, efficient and economical way. It is referred to a hypothesis testing or a deductive research method. It seeks to determine a relationship between a dependent and an independent variable. The results of it are not known in advance. It is the process of planning a study to meet specified objectives. Here one or more independent variables are manipulated and applied to one or more dependent variables to measure their effects on the latter. In this type of research the researchers design the specific conditions to test their theories or propositions, controlling the experiment and collecting their data to isolate the relationships between their defined independent variables and dependent variables (Swanson & Holton, 2005). It consists of making an observable and quantifiable change in the independent variable, and then observing how that affects the dependent variables (Leedy & Ormrod, 2001).

During the experimental research, the researcher investigates the treatment of an intervention into the study group and then measures the outcomes of the treatment. Experiments consist of making an observable and quantifiable change in one variable (the independent variable) and then observing how that affects other variables (the dependent variables) (Chen, 2011).

The goal of it is to test hypothesis to establish cause and affect relationships (Ary et al., 2010). Some advantages of experimental research according to Mildner

(2019) are: it controls the independent variables. It is straightforward determination of causal relationships, possibility of verifying results through repeatability/replicability, and the opportunity to create conditions that are not easily observed in natural settings or would take too long. Some disadvantages of experimental research are it is unnaturalness; difficulty to apply the results to real-life situations, and ethical considerations, it cannot be applied to all types of research problems, and results may appear significant because of experimenter error or the inability to control for all extraneous variables (Mildner). There are three types of exploratory approaches: pre-experimental, true experimental and quasi-experimental (Leedy & Ormrod, 2001; Ary et al., 2010).

The word “quasi” means partial, half, or pseudo. The quasi-experimental design involves non-random selection of study participants, where control is limited and true experimentation is impossible or difficult (Harris et al., 2004). It has both pre- and post-test and experimental and control groups, but no random assignments of subjects. Since the variable cannot be controlled, validity may be sacrificed (Campbell & Stanley, 1963). For example, two sick people of the same age and same physical structure are given same antibiotic, and one of them given an additional antibiotic with the common antibiotic. After seven days the two patients are examined, and their health condition is measured. The lack of random assignment is the major weakness of the quasi-experimental research. Statistical association does not imply causal association if the study is poorly designed (Harris et al., 2004).

(ii) Non-Experimental Research: It lacks the manipulation of an independent variables, random assignment a researcher simply measures variables as they occur. Non-experimental research is divided into the word “quasi” means partial, half, or pseudo. It lacks the manipulation of an independent variables, random assignment a researcher simply measures variables as they occur. Non-experimental research can be statistical research and tries to study frequencies, averages, and other statistical calculations. It generates data, both qualitative and quantitative, that define the state of nature at a point in time. It attempts to describe, explain and interpret conditions of the present (Koh & Owen, 2000). It is a basic research method that examines the current situation. It identifies the characteristics of an observed phenomenon, or explores correlations between two or more entities, and nothing is controlled or manipulated. In this type of research, a researcher is able to collect a large amount of data. It cannot be used as the basis of a causal relationship where one variable affects another. It is sometimes contrasted with hypothesis driven research, which is focused on testing a particular hypothesis by means of experimentation (Casadevall & Fang, 2008).

Types of Quantitative Research

The three types of quantitative are: observation studies, correlational research, and survey research.

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(a) Observation Studies

Observation study is one of the most important research methods in natural and social sciences, and has been used for collecting data about people, processes, and cultures in qualitative research. It is used for referring several different types of non-experimental studies in which behavior is systematically observed and recorded. It is an ethnographic research method and it seems that there is no specific beginning of it. But some researchers stated that use of it was started in the late 19th and beginning of the 20th centuries (Baker, 2006). Greek philosopher Aristotle used observational techniques in his botanical studies on the island of Lesbos. Auguste Comte (1798–1857), the father of sociology, listed observation as one of the four core research methods [Adler & Adler, 1994]. Observation is a preplanned research tool which is carried out purposefully to serve research questions and objectives. It is related to positivist research (Angrosino, 2005). It enables the researcher to combine it with questionnaires and interviews to collect objective information (Johnson & Turner, 2003). Observation studies include the systematic recording of observable phenomena (Gorman & Clayton, 2005).

Observation study is the least intrusive data collection method and can be an abuse of an individual's privacy (Adler & Adler, 1994). Observation data is collected by naturalistic enquiry using a structured, unstructured or semi-structured approach (Fry et al., 2017). An individual's privacy cannot be abused and a researcher must be unbiased during data collection. It is often criticized for lacking reliability (Adler & Adler, 1994). It is time-consuming, costly; practically challenging and a variety of techniques are used to collect data. For the collection of data a researcher needs specialized training on how to observe, what and how to record the data, how to enter the field and leave it, length of time in the field, sampling and data collection techniques, etc. Hence it is a complex and challenging research method (Baker, 2006).

Direct observation is called gold standard among qualitative data collection techniques (Murphy & Dingwall, 2007). Observation data collection can improve understanding of practice, processes, knowledge, beliefs, and attitudes embedded in social interactions [Fry et al., 2017]. Some advantages of observational research are as follows (Foster, 2006):

- Research information can be revealed carefully, planned observation by a researcher over a period of time,
- Observational data seem more accurate,
- The observer sees but participants cannot,
- Observation can provide information of those who cannot speak (e.g., babies, very young children and animals), and
- Data collected from observation can check on, and supplement to, information obtained from other sources. Researcher's preconceptions and existing knowledge will bias observation, and
- It is very time consuming and costly.

(b) Correlational Research

Francis Galton (1822–1911) for the first time provided the idea of correlation in 1898 but Karl Pearson (1857–1936) developed and promoted it as scientific concept of universal significance (Aldrick, 1995). It is a type of quantitative research method within the positivism paradigm. Mainly three types of correlational research have been identified: positive correlation, negative correlation, and no correlation research (Anderson & Arsenault, 1998).

A researcher's preconceptions and existing knowledge will bias observation, and it is very time consuming and costly. Correlational Research: The term „correlation“ is a common and useful statistical concept applied in research. Francis Galton (1822–1911) for the first time provided the idea of correlation in 1898 but Karl Pearson (1857–1936) developed and promoted it as scientific concept of universal significance (Aldrick, 1995). It is a type of quantitative research method within the positivism paradigm. Mainly three types of correlational research have been identified: positive correlation, negative correlation, and no correlation research (Anderson & Arsenault, 1998).

(c) Survey Research

Among many types of quantitative research, survey research is very popular in the natural and social sciences, which includes questionnaires, personal interviews, phone surveys, and normative surveys. In a country, survey is conducted for the economic, social, political, and cultural shape (Bethlehem, 2009). It is the systematic gathering of information from respondents for the purpose of understanding and predicting some aspects of the behavior of the population of interest. The survey research was invented by Paul Lazarsfeld, George Gallup and Hadley Cantril (Glasow, 2005; Sukamolson, 2007). It focuses on people, the vital facts of people, their beliefs, opinions, attitudes, motivations and behavior (Kerlinger & Lee, 2000).

Survey research is a study on large and small populations by selecting samples chosen from the desired population and to discover relative incidence, distribution and interrelations (Kerlinger & Lee, 2000). It provides an important source of basic scientific knowledge. It uses scientific sampling and questionnaire design to measure characteristics of the population with statistical precision (Sukamolson, 2007). It is the best method of data collection, when the researcher is interested in collecting original data for a population that is too big to test directly (Babbie, 2001).

Generally many researchers conduct survey studies, such as economists for income and expenditure patterns among households, educationists for factors influencing academic performance, health professionals for the implications of health problems on people's lives, psychologists for the roots of ethnic or racial prejudice, political scientists for comparative voting behavior, sociologists for the effects on family life of women working outside the home, etc. (de Leeuw et al., 2008; Kothari, 2008; Creswell, 2011). It is the most common type of descriptive

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research in dietetic, nutrition, and health areas, which involves asking questions of a sample of individuals who are representative of the group or groups being studied (Koh & Owen, 2000).

In survey research biases may occur and respondents may have difficulty assessing their own behavior. It is unsuitable where an understanding of the historical context of phenomena is required (Pinsonneault & Kraemer, 1993). Survey does not show exact measurements; only provide estimates for the true population (Salant & Dillman, 1994). There are two types of survey: cross-sectional survey and longitudinal survey. The key difference between them is that first one occurs once whereas the latter takes place on multiple occasions over time (Lynn, 2009).

Cross-Sectional Survey: A survey which is carried out at a just one-point in time or over a short period is known as cross-sectional or prevalence study. It is a type of observational study design. It is selected based on the inclusion and exclusion criteria set for the study. It is used for population based surveys and to assess the prevalence of diseases in clinic based samples (Ross & Vaughan, 1986; Setia, 2016). It provides a snapshot of what is happening in that group at that particular time. It is used if the study is descriptive and survey related. It sometimes investigates associations between risk factors and the outcome of interest (Levin, 2006). It tells us what people are thinking or doing at one point in time. It is useful in assessing practices, attitudes, knowledge and beliefs of a population in relation to a particular health related event (Buck, 2008). If the research needs a pool of opinions and practices, a cross-sectional survey would be appropriate and collects information from a sample drawn from a population at one point of time. The period of data collection can vary and it depends on the study weight age (Ross & Vaughan, 1986; Mathers et al., 2009).

Longitudinal Survey: In 1759, Gueneau de Montbeillard first has recorded the longitudinal study, but in the 1920s the study has advanced when a monumental work was undertaken by Lewis M. Terman of Stanford University to study the developmental histories of gifted children (Buffon, 1837; Rajulton, 2001). A longitudinal survey rather than taking a snapshot, paints a picture of events or attitudes over prolonged periods of time, often years or decades. It is used in social science, natural science and health research (e.g., clinical pathology, public health, child development, adolescent psychosocial development, genetic classification, epidemiological case registers, etc.) to study rapid fluctuations in behaviors, thoughts, and emotions from moment to moment in processes in human and technical systems. It makes observing changes more accurate and is applied in various other fields (Venkatesh & Vitalari, 1991; Carlson et al., 2009). Organizational science researchers apply it to understand changes in organizational structure, causal mechanisms, and organizational adaptation (Tuma & Hannan, 1984).

Characteristics of Quantitative Research

Characteristics of quantitative research are associated with positive paradigm. A quantitative research approach is characterized as being structured with predetermined variables, hypotheses and design (Bryman, 2012; Creswell, 2011). It employs the traditional, the positivist, the experimental, or the empiricist method to enquire into an identified problem (Smith, 1975). It is used to get answers in numerical form which makes relationship between an independent variable and a dependent variable within a large population.

A numerical output is easy to read and understand, and it is easy to deduce a conclusion from the numerical outcome than a detailed result. Here the output is usually found in the form of graphs, range of numbers, statistical data, tables, and percentages, etc. to show trends, relationships, or differences among variables. In quantitative research close-ended questionnaires are used whose answers are more specific and right than the open-ended questionnaires which are more detailed and scattered. Moreover, responses to the close-ended questionnaires are more reliable than the answers to open-ended questionnaires (Polit & Beck, 2017).

Quantitative research has the following major characteristics (Brink & Wood, 1998; Burns & Grove, 2005):

- i. All aspects of the study are carefully designed before quantitative research data collection.
- ii. Data are collected in the form of numbers and statistics, often arranged in tables, charts, figures, percentage, or other non-textual forms. A numerical output is easy to read and understand, and deduce a meaningful conclusion than a detailed result.
- iii. The data are usually collected using structured research modern instruments, such as questionnaires or computer software are used to collect numerical data.
- iv. Statistical analysis is conducted to reduce and organize data, determine significant relationships and identify differences or similarities within and between different categories of data.
- v. Data gathering instruments contain items that solicit measurable characteristics of the population (e.g., age, the number of children, educational status, economic status, etc.).
- vi. The results are based on larger sample sizes that are representative of the population.
- vii. It is usually concise.
- viii. It provides an accurate account of characteristics of particular individuals, situations, or groups.
- ix. It emphasis on the procedures of comparing groups or relating factors about individuals or groups in experiments, correlational studies, and surveys.
- x. Standardized, pre-tested instruments guide data collection ensures the accuracy, quite reliability as participants of the research face close-ended questions, and high validity of data for repeated research study.

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- xi. Moreover, the outcome of quantitative research is easy to understand and explain.

Strengths of Quantitative Research

Quantitative research applies statistical tests, such as mean, median, and standard deviation, t-tests, multiple regression correlations (MRC), analysis of variances (ANOVAs), etc. Quantitative data are usually collected by surveys from large numbers of respondents randomly selected for inclusion. Sometimes secondary data, such as government statistics, census data, health system metrics, etc. are included in quantitative research. Walker (2005), Atieno (2009) and Choy (2014) identified some strengths of quantitative research are as follows:

- i. Results from sample surveys can be generalized for entire populations.
- ii. Relatively easy to analyze.
- iii. Results can be aggregated and are comparable across population groups.
- iv. Results can be broken down by socio-economic group for comparisons.
- v. Findings can be generalized if selection process is well-designed and sample is representative of study population.
- vi. Reliability of data and findings provides powerful indicators to guide policy.
- vii. Replicability publication of questionnaires and dataset permits scrutiny of findings.
- viii. Transferability of dataset to other analysts means that analysis is not dependent on availability of an individual.
- ix. Data can be very consistent, precise and reliable.
- x. Precise professional or disciplinary minimum standards exist for much survey work.
- xi. Statistical methods mean that the analysis is often considered reliable. Appropriate for situations where systematic, standardized comparisons are needed.

Weaknesses of Quantitative Research No doubt quantitative research is strong enough but has some weaknesses. Walker (2005), Atieno (2009) and Choy (2014) identified some weaknesses of quantitative research are as follows

It sacrifices potentially useful information through process of aggregation.

- i. It provides useful data by placing households or events in discrete categories.
- ii. It neglects intra-household processes and outcomes.
- iii. It commonly under-reports on difficult issues, such as domestic violence and difficult to access individuals and households.
- iv. Large amounts of the dataset are never used if the project is very expensive.
- v. Poorly trained enumerators can make mistakes and inadvertently influence responses.
- vi. Enumerators may give false data.
- vii. May give a false impression of homogeneity in a sample.

Advantages of Quantitative Research

In quantitative research statistical, computational, mathematical techniques, etc. are applied, i.e., it looks at measurable, numerical relationships to obtain the accurate result. It is often seen as more accurate than qualitative research, which focuses on gathering non-numerical data (Bryman, 2012; Goertz & Mahoney, 2012). In quantitative research the statistical package for social science (SPSS) are used and data are calculated and conducted by computer, it saved time and resources. Indeed, it is scientific in nature and research findings are more reliable (Connolly, 2007).

Walker (2005), Atieno (2009) and Choy (2014) identified some identified some advantages of quantitative research are as follows:

- i. It requires careful experimental design and the ability for anyone to replicate both the test and the results.
- ii. It allows the researcher to measure and analyze data.
- iii. It strives to control for bias so that facts, instances, and phenomena can be understood in an objective way.
- iv. It allows for statistical comparison between various groups.
- v. The data is considered quantifiable and usually generalizable to a larger population.
- vi. Test hypotheses are used in experiments because of its ability to measure data using statistics.
- vii. As statistical tests are appropriately use, less error occur during the research.
- viii. Relationship between an independent and dependent variable is studied in detail, which is advantageous because the researcher is more objective about the findings of the research.
- ix. It emphasizes large samples that can provide an overview of an area that can reveal patterns, inconsistencies, and so forth.
- x. It measures level of occurrence, actions, trends, etc.
- xi. It can provide a clear, quantitative measure to be used for grants and proposals.
- xii. It has precision, is definitive and standardized.
- xiii. It can be used when large quantities of data need to be collected.
- xiv. It indicates the extensiveness of attitudes held by people.

Disadvantages of Quantitative Research

Qualitative research is very popular and strong but; it has also some disadvantages. It strictly follows statistical relationships that overlook broader themes and relationships. As a result, it has a risk of missing important information of research (Bryman, 2012; Goertz & Mahoney, 2012). Walker (2005), Atieno (2009) and Choy (2014) identified some disadvantages of quantitative research are as follows:

- i. Results need to be calculated using Excel, Access, or SPSS, which may not always be accessible to a country program.
- ii. It can be limited in its pursuit of concrete, statistical relationships.

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- iii. The bias occurs earlier in the process of quantitative research.
- iv. The context of the study or experiment is ignored.
- v. It is difficult to understand context of a phenomenon.
- vi. Related secondary data is sometimes not available.
- vii. Data may not be robust enough to explain complex issues.
- viii. It is time consuming. The larger the sample, the more time it takes to analyze the data and analyze results.
- ix. It ignores a very important human element.

Quantitative Evaluation

Quantitative evaluation criteria comprised of the combination of validity, reliability and generalizability. Validity is confirmed if results from a randomised sample with the assurance that conflict of interest have been minimised. Reliability is verified with an adequate sample size so that conclusions can be drawn with precision and accuracy (Mohajan, 2017). Generalisability is of necessary as, it allows the results to be applied to the population at large (Morris & Burkett, 2011).

Ethical Reflections Ethics pertain to morally good or correct practice and avoid any harm that may emanate during the study. Ethics are essential in any research (Lillemoen & Pedersen, 2013). Strength and integrity are useful for successful quantitative research. These depend on how the researchers design their researches. Ethic is an important characteristic in any research, which is about professional regulations and codes of conduct that guide the researcher in his dealings with participants (Denzin & Lincoln, 2005).

In any research respondents are assured that their names and the names of their organizations would be dealt with in the strictest confidence. Their trust would not be exploited for personal gain or benefit, by deceiving or betraying them in the research (Lubbe, 2003). Researchers must “do no harm” as they collect data from someone and report findings to someone (Berg & Howard, 2012). An ethical challenge happens where there are doubts, uncertainties or disagreements about what is morally good or correct practice and avoids any harm (Lillemoen & Pedersen, 2013).

Sometimes researchers do not follow the ethical characteristics during this type of research. For example, during World War II, Nazi scientists conducted some experiments, such as immersing people in ice water to know how long it would take them to freeze into death. They also injected prisoners with newly developed drugs to know their effectiveness; consequently many died in the process, which are unethical and inhumane (Christensen, 1988). According to Neuman (2012) “Ethics begins and ends with you, the researcher”. According to him some general ethical issues in research that result in some prohibitions are:

- i. Never cause unnecessary or irreversible harm to participants,
- ii. Secure prior voluntary consent when possible and never unnecessarily humiliate, and

- iii. Degrade, or release harmful information about specific individuals that was collected for research purposes. In this study we have tried to maintain ethics strictly.

In the theoretical analysis we have given proper references in the research. We have maintained the ethical formalities throughout the study (Mohajan, 2018b).

Conclusions

In this study we have tried to discuss the components of quantitative research methodology in a systematic and logical order. We observe that this type of research is highly structured, and the results are determined numerically or statistically. Researchers prefer quantitative research for its creative characteristics and strengths. Worldwide it is one of the most used approaches to conduct natural and social science researches. In the study we have observe that the quantitative research methodology is founded on the scientific method. It uses experimental and observed measurements to develop theories and advance knowledge in the research area. In this type of research, the variables are clearly defined and results seem very accurate, as the results are obtained by mathematical formulae and statistical analyses. We have discussed types of quantitative research. We have also briefly overviewed the characteristics, strengths, weaknesses, advantages, and disadvantages, ethical reflections of this type of research. A researcher must be more conscious during data collection and interpretation to avoid bias in quantitative research. We hope that this review paper will help new researchers to write qualitative research articles accurately and efficiently.

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