Quantitative research design

Jacqueline Bloomfield* *PhD, MN, PGDip (Healthcare Ed), PGDip (Midwifery), BN, RN*
Associate Professor, Susan Wakil School of Nursing and Midwifery, University of Sydney, NSW
88 Mallett Street, Camperdown, NSW 2050
Email Jacqueline.Bloomfield@sydney.edu.au

Murray J Fisher *RN, ICT Cert, DipAppSc (Nursing), BHSc (Nursing), MHPEd, PhD*
Associate Professor, Susan Wakil School of Nursing and Midwifery, University of Sydney and Nursing Scholar in Residence, Royal Rehab, Ryde NSW.
**Corresponding author*

Key words Evidence-based practice, research process, nursing, research
For referencing Bloomfield J & Fisher MJ. Quantitative research design. *JARNA* 2019; 22(2):27-30.
DOI https://doi.org/10.33235/jarna.22.2.27-30

Introduction

This paper is the third in a series of articles about research methods. Previous papers in this series have focused on research paradigms (Davies & Fisher, 2018) and the research process (Fisher & Bloomfield, 2019). The aim of this article is to explain what is meant by research design and to discuss the four different types of research design that are commonly used in quantitative research. How a researcher designs, structures and implements a study can affect the research findings and is an important consideration regarding bias. It is therefore important that nurses reading and critiquing research papers have a sound understanding of the concept of research design and are able to identify any flaws in the study design that may interfere with reported study findings.

Research design

In simple terms, a research design can be described as the overall strategy that is used to conduct a research study. More specifically, a research design is the blueprint or plan that will be used by researchers to answer a specific research question. Essentially, a research design comprises three distinct elements – a plan, a structure and a strategy (Burns, Grove, & Gray, 2015). Consideration of these three elements will assist the researcher in determining the hypothesis, conducting the study, and analysing and interpreting the data. In quantitative research, it is imperative that control is maintained. Control refers to the methods the researcher will use to prevent or minimise any factors that may influence or bias the findings. To understand more about the importance of control in quantitative research design, it is relevant to revise the key characteristics or assumptions that underpin quantitative research.

Quantitative research

Quantitative research can be defined as a "formal, objective, systematic process used to describe variables, test relationships between them, and examine cause and effect associations between variables" (Burns et al., 2015, p. 510). Quantitative research generates numerical data, is predominantly informed by positivist or post-positivist paradigms, and is underpinned by a number of assumptions (Davies & Fisher, 2018). These include, among others, the belief in a single truth or reality, objectivity, and deduction. As such, quantitative research seeks to find the true answer by testing hypotheses using objective and impartial scientific methods (Davies & Fisher, 2018).

Quantitative research tests a hypothesis – usually the null hypothesis, the assumption about the relationships between dependent and independent variables – by drawing a representative sample of participants from a known population, measuring the variables, and testing them using statistical analyses. The null hypothesis assumes that there is no relationship between dependent and independent variables. The null hypotheses is then either accepted or rejected based on the outcomes of the statistical analyses. Inferences or generalisations can then be applied to the population of interest. In order to have confidence in the ability to make generalisations about a population, the research design must be reliable, and have internal and external validity. Collectively, these factors are known as rigour.

Rigour in quantitative research can be described as the amount of control the researcher exerts to prevent the effects of extraneous or confounding variables on the dependent (test or outcome) variable (Shields & Smyth, 2016). In order to determine the effect of an independent variable, the researcher should control for outside effects (confounding effects) of any other variables or phenomena that may have an influence on the dependent (outcome) variable. For example, to create a falls risk profile, a researcher needs to compare the characteristics of a sample of patients who have experienced a fall with those of a sample of patients who have not had a fall. In this situation if there is an error in sample selection of the non-falling patient group and this group accidently consists of a higher mean for age, then the difference – or not – between the two groups may be due to age as a result of the sampling error.

Types of quantitative research design

A range of different study designs are used in quantitative research – these may vary in the ways in which these are categorised according to different textbooks and reference materials. For the purpose of this article, the authors have adopted the classification system utilised by authors such as Burns et al. (2015) and Borbasi & Jackson (2012) who describe four major types of quantitative research – descriptive, correlational, quasi-experimental and experimental. A summary of the main features of these are presented in Table 1 and are discussed below.

Descriptive research design

The purpose of a descriptive quantitative study is to examine variables in a single sample and to systematically measure, describe and interpret them. Descriptive research design is typically used to obtain information about a particular phenomenon or characteristic of interest in an identified sample or population in their natural setting. For example, a researcher might conduct a descriptive quantitative research study, using a validated survey, to quantify how many people in a sample of patients hospitalised with severe spinal cord injury reported feelings of depression and anxiety during the past week. Importantly, this type of research does not involve the control or manipulation of variables in any way.

Research studies that are used to describe variables and examine variables in two or more groups are referred to as comparative descriptive design

Research studies that are used to describe variables and examine variables in two or more groups are referred to as comparative descriptive design (Burns et al., 2015). The variable/s of interest are measured and described in both groups and are then compared. For example, researchers might conduct a comparative descriptive study to describe the differences in educational qualifications in male nurses and female nurses employed at a local hospital.

Findings from descriptive research studies are most valuable in determining the frequency to which something exists. They are also useful for describing a particular phenomenon which is new, or about which very little is known. However, while findings cannot be used to establish cause and effect, they may be useful

Table 1. Types, features and examples of quantitative research design (Burns et al, 2015).

Type of quantitative research design	Features	Example
Descriptive	Is used to describe a phenomenon in a real-life setting. Quantifies characteristics of identified individuals, groups or situations. Is typically conducted with large numbers. Does not involve manipulation of variables .	A description of patients treated in a hospital ward over a 12-month period.
Correlational	Investigates the relationship between or among selected variables in a sample by using correlational statistics. Determines the degree, strength and type of the relationship between variables. Does not determine cause and effect.	A study of the relationship between exercise levels and obesity in male nurses.
Quasi-experimental	Examines causal relationships or determines the effect of one variable on another. Lacks the level of control achieved in experimental studies.	A study of the effect of patient discharge education on hospital re-admission rates.
Experimental	Examines causal relationships between dependent and independent variables under highly controlled conditions. Involves the manipulation of independent variable/s, random assignment of subjects to the experimental or control group, and exposure of the experimental group to at least one intervention and the control group to none.	A study of a new anti-hypertensive medication in middle-aged females diagnosed with hypertension.

in the development of hypotheses that can be tested in future studies.

It is imperative that researchers use methods to ensure that the data collected is both reliable and valid. This includes the use of a sample that is of adequate size and that accurately represents the target population by using a probability sampling technique. Instruments and methods most commonly used to collect data in descriptive studies include surveys, checklists, observations, interviews or equipment to measure physiological variables such as weight scales and thermometers. It is also important that these are calibrated, standardised and piloted prior to use to ensure internal validity.

Correlational research design

Correlational research aims to determine whether two or more variables are related and, if so, to discover the nature of the relationship. In other words, it seeks to establish associations or correlations between variables. Like descriptive research, the variables being investigated in correlational studies are not manipulated and the research does not seek to determine cause or effect. Instead, correlational studies can be used to describe or predict relationships or to test theoretical models of relationships (Shields & Smyth, 2016).

The findings from correlational studies are expressed using statistics and can be explained in three ways – positive correlation, negative correlation and no correlation

The findings from correlational studies are expressed using statistics and can be explained in three ways – positive correlation, negative correlation and no correlation. A positive correlation is a relationship that exists between two variables in which both variables either increase or decrease at the same time. For example, the amount of food a person consumes might correlate positively with their weight. A negative correlation between variables occurs when an increase in one variable results in a decrease in another and vice versa. For example, the more food a person consumes, the lower their hunger levels will be. Two variables are said to be uncorrelated when an alteration in one does not lead to an alternation in the other and vice versa. For example, the time someone spends riding a bicycle does not necessarily correlate with their level of cardiac fitness.

A statistical value known as a correlation coefficient is typically used to report the findings of correlational studies. This value will differ between +1 and −1, with a number close to +1 denoting a strong positive relationship while a value close to −1 indicates a strong negative correlation. A value close to zero denotes that the variables are not correlated (Fisher & Fethney, 2016).

Quasi-experimental research design

The third category of quantitative research design is quasi-experimental studies. These are similar to experimental studies in that they aim to test the effectiveness of interventions, and therefore involve the manipulation of an independent variable (Harris et al., 2006). However, unlike a true experimental study (for example a randomised controlled trial), they lack the random allocation of participants to certain conditions, such as an intervention/experimental or control group. This may have considerable implications in that any factors other than those being investigated may have an effect on the findings. These are known as confounding or extraneous variables.

Quasi-experiments are typically carried out in settings when it is not logistically feasible nor ethical to conduct a randomised controlled trial, and are therefore commonly used in the healthcare setting. There are different types of quasi-experimental studies that include, among others, non-equivalent control pre-test–post-test design, non-equivalent control post-test only design, one group pre-test–post-test design and time-interrupted series. Features of these are summarised in Table 2.

Experimental research design

The fourth category of quantitative research design is experimental study design. Experimental study design has the greatest level of control and, as such, has frequently been identified as the gold standard of quantitative research (Shields and Smyth, 2016). This is due to its ability to determine a cause-and-effect relationship between an intervention (the cause) and the study outcome (the effect). Key components of an experimental design study include:

- Random assignment of participants into groups with allocation concealment.
- A control or comparison group.
- Researcher-controlled manipulation of the dependent variable (intervention).
- Blinding of the participants, researchers and assessors to the allocation of participants to test groups.

As the purpose of experimental studies are to determine cause-and-effect relationships between independent (intervention vs control) and dependent (outcome) variables, the allocation of participants into the intervention and control groups should be randomly sequenced. Allocation concealment occurs when the person allocating participants into the groups is unaware of the random sequence. This will help to prevent selection bias by

Table 2. Features of quasi-experimental research design.

Type	Feature	Test groups
Non-equivalent control pre-test–post-test	Non-randomly assigned control	*Experimental group* Pre-test → Intervention → Post-test *Control* Pre-test → Placebo/normal care → Post-test
Non-equivalent control post-test only design	Non-randomly assigned control	*Experimental group* Intervention → Post-test *Control* Placebo/normal care → Post-test
One group pre-test–post-test design	No control group	*Experimental group* Pre-test → Intervention → Post-test
Time-interrupted series	Non-randomly assigned control or no control group	*Experimental group* Pre-test → Intervention → Post-test → Follow-up post-test *Control* Pre-test → Placebo/normal care → Post-test → Follow-up post-test

ensuring both groups are equivalent. That is, both groups will potentially have the same characteristics, therefore limiting any extraneous effects that could be introduced if the samples were different.

Blinding the participants, researchers and assessors to the allocation of participants to either the intervention group or control group also prevents the introduction of bias. Having the knowledge of group allocation may influence the behaviour of participants, researchers or assessors and therefore potentially add bias to the study outcomes. Blinding participants is particularly important when the outcome measure is a self-report measure such as those used in surveys.

There are different types of experimental research design, including parallel, crossover, factorial and cluster design. In a parallel design, participants are randomly assigned to receive either the intervention or control. In a crossover design, participants are firstly assigned to either the intervention or control and, after a period of time, will crossover and receive the alternate, that is the intervention group will receive the control and the control group will receive the intervention. In a crossover design, each individual becomes their own control, therefore negating bias from individual differences. A factorial design examines multiple interventions at the same time and requires multiple arms to the study. In a 2x2 factorial study, participants may be assigned to a control, intervention A, intervention B and intervention A+B group. In this study design, intervention A and intervention B are compared to the control as well as the combined effect of intervention A+B. In nursing it is not always possible to randomise individuals to receive different interventions. To overcome this, groups or clusters of individuals (for example wards, units or hospitals) can be randomly assigned to either the control or intervention and all members of the cluster will receive the allocation. This is known as a cluster trial.

Conclusion

Quantitative research has a very important role in nursing and healthcare and can be utilised to measure variables and determine the effect of interventions. Unlike qualitative research, which values subjectiveness and seeks to explore and interpret the individual experience of a phenomenon, quantitative researchers adopt an objective perspective and strive to minimise bias. As described in this article, there are four main categories of quantitative research design, each with their own distinctive features, purpose, and rigour. An understanding of quantitative research design is essential for nurses who are engaged in evidence-based practice as this will enhance their ability to understand and critique the research literature and potentially integrate study findings and recommendations into their own practice.

References

Borbasi, S., & Jackson, D. (2012). *Navigating the maze of research.* Chatswood, NSW: Mosby Elsevier.

Burns, N., Grove, S. K., & Gray, J. (2015). *Understanding nursing research: Building on evidence-based practice* (6th ed.). St Louis, MI: Elseiver Saunders.

Davies, C., & Fisher, M. (2018). Understanding research paradigms. *Journal of the Australasian Rehabilitation Nurses' Association, 21*(3), 21–25.

Fisher, M., & Bloomfield, J. (2019). Understanding the research process. *Journal of the Australasian Rehabilitation Nurses' Association, 22*(1), 22–27.

Fisher, M. J., & Fethney, J. (2016). Analysing data in quantitative research. In Z. Schneider, D. Whitehead, G. Lobiondo-Wood & J. Harber (Eds.), *Nursing and midwifery research: Methods, critical appraisal and utilisation* (5th ed.). Sydney, NSW: Mosby.

Harris, A. D., McGregor, C, Perencevich, E. N., Furuno, J. P, Zhu, J., Peterson, D. E., & Finkelstein, J. (2006). The use and interpretation of quasi-experimental studies in medical Informatics. *Journal of American Medical Informatic Association, 13*(1), 16–23.

Shields, L., & Smyth, W. (2016). Common quantitative methods. In Z. Schneider, D. Whitehead, G. Lobiondo-Wood & J. Harber (Eds.), *Nursing and midwifery research: Methods, critical appraisal and utilisation* (5th ed.). Sydney, NSW: Mosby.