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When you have to be right

Chapter 9
Quantitative Research Design

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Key Features of Quantitative Research Design: Interventions

- Key questions
  - Will there be an intervention?
  - What **specific design** will be used?
- Broad design options
  - Experimental (randomized control trial)
  - Quasi-experimental (controlled trial without randomization)
  - Nonexperimental (observational study)

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Key Features of Quantitative Research Design: Comparisons

- Key question
  - **What type of comparisons** will be made to illuminate relationships?
- Some design options
  - **Within-subjects design**: Same people are compared at different times or under different conditions.
  - **Between-subjects design**: Different people are compared (e.g., men and women).

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Other Key Features of Quantitative Research Design

- Control over confounding variables
  - **How** will confounding variables be controlled?
  - Which **specific** confounding variables will be controlled?
  - Randomization, crossover, homogeneity, matching, statistical control

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Other Key Features of Quantitative Research Design—(cont.)

- Masking/blinding
  - From whom will critical information be withheld to avert bias?
- Time frames
  - **How often** will data be collected?
  - **When**, relative to other events, will data be collected?
  - Cross-sectional, longitudinal design

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Other Key Features of Quantitative Research Design—(cont.)

- Relative timing
  - When will information on independent and dependent variables be collected—looking forward or backward in time?
  - Retrospective (case-control), prospective (cohort)
- Location
  - **Where** will the study take place?
  - Setting choice; single site versus multisite

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Question

Tell whether the following statement is True or False.

An experimental research design involves a nonrandomized controlled trial.

a. True

b. False

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Answer

b. False

Rationale: A quasi-experimental research design involves a controlled trial without randomization.

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What is "Causality"?

- Many (if not most) quantitative research questions are about **causes** and **effects**.
- Research questions that seek to illuminate causal relationships need to be addressed with appropriate designs.

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The Counterfactual Model of Causality

- A **counterfactual** is what would have happened to the same people exposed to a "cause" if they simultaneously were **not** exposed to the cause.
- An **effect** represents the difference between what actually did happen when exposed to the cause and what would happen with the counterfactual condition.

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Criteria for Causality

- Three key criteria for making causal inferences
  - **Temporal**: The cause **must precede the effect** in time.
  - **Relationship**: There **must be a demonstrated association** between the cause and the effect.
  - **Confounder**: The relationship between the presumed cause and effect **cannot be explained by a third variable or confounder**; another factor related to both the presumed cause and effect cannot be the "real" cause.

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Additional Criteria for Causality

- Additional criterion in health research
  - **Biologic plausibility**: The causal relationship should be consistent with evidence from basic physiologic studies.

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Research Questions and Research Design

- Different designs are appropriate for different questions.
  - Therapy, prognosis, etiology/harm, and description
- Experimental designs (RCTs) offer the strongest evidence of whether a cause (an intervention) results in an effect (a desired outcome).
  - That's why they are high on evidence hierarchies for questions about causes and effects.

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Experimental Design (has intervention)

- **Intervention**: The researcher does something to some subjects—introduces an **intervention** (or **treatment**).
- **Control**: The researcher introduces controls, including the use of a control group counterfactual.
- **Randomization**: The experimenter assigns participants to a control or experimental condition on a random basis.
  - The purpose is to make the groups equal with regard to **all other factors** except receipt of the intervention.

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Question

Which characteristic is a key criterion for causality?

a. Cause occurring before the effect
b. Third variable involved with the cause and effect
c. No empirical relationship between the cause and effect
d. Single-source evidence about the relationship

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Answer

a. Cause occurring before the effect

Rationale: Three key criteria for causality include the following:

- The cause must precede the effect in time.
- There must be a demonstrated empirical relationship between the cause and effect.
- The relationship cannot be explained by a third variable.

An additional criterion is that evidence of the relationship should come from multiple sources.

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Experimental Designs

- **Posttest-only (or after-only) design**
  - Outcome data collected only after the intervention
  - Symbolic representation:

    R X O

    R O
  - R = Randomization; X = Receipt of intervention; O = Observation/measurement of dependent variable

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Experimental Designs—(cont.)

- **Pretest–posttest (before–after) design**
  - Outcome data collected both at **baseline** and after the intervention
  - Symbolic representation:

    R O X O

    R O O

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Experimental Designs—(cont.)

- **Crossover design**
  - Subjects are exposed to 2+ conditions in random order.
  - Subjects serve as their own control.
  - Symbolic representation:

R	O	X_A	O	X_B	O
R	O	X_B	O	X_A	O

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Experimental Condition

- Must be designed with sufficient intensity and duration that effects might reasonably be expected
- Researchers describe the intervention in formal *protocols* that stipulate exactly what the treatment is.
- Attention must be paid to **intervention fidelity** (or treatment fidelity), that is, whether the treatment as planned was actually delivered and received.

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Control Group Conditions (Counterfactuals)

- No intervention is used; control group gets no treatment at all.
- "Usual care" or standard or normal procedures is used to treat patients.
- An alternative intervention is used (e.g., auditory vs. visual stimulation).
- A **placebo** or pseudointervention, presumed to have no therapeutic value, is used.
- Attention control condition and delayed treatment (wait-listed)

Control Group Conditions—(cont.)

- **Attention control**—extra attention but not the active ingredient of the intervention
- **Delayed treatment ("wait-listed controls")**—the intervention is given at a later date.
  - Symbolic representation:

R	O	X	O		O
R	O		O	X	O

Advantages and Disadvantages of Experiments

- **Advantages**—most powerful for detecting cause and effect relationships
- **Disadvantages**—often not feasible or ethical, Hawthorne effect (knowledge of being in a study may cause people to change their behavior), often expensive

Question

Tell whether the following statement is True or False.

A true experiment requires that the researcher manipulate the independent variable by administering an experimental treatment (or intervention) to some subjects while withholding it from others.

a. True

b. False

Answer

a. True

Rationale: In a true experiment, the researcher manipulates or does something, usually an intervention or treatment, to some subjects and not to others.

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Quasi-Experiments

- Involve an intervention but lack either randomization or control group
- Two main categories of quasi-experimental designs
  - Nonequivalent control group designs
    - Those getting the intervention are compared with a nonrandomized comparison group.
  - Within-subjects designs
    - One group is studied before and after the intervention.

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Nonequivalent Control Group Designs

- If preintervention data are gathered, then the comparability of the experimental and comparison groups at the start of the study can be examined.
  - **Nonequivalent control group pretest–posttest design**
  - Symbolic representation:

$O_1 \quad X \quad O_2$

$O_1 \qquad O_2$

Nonequivalent Control Group Designs—(cont.)

- Without preintervention data, it is risky to assume the groups were similar at the outset.
  - **Nonequivalent control group posttest only** is **much** weaker.
  - Symbolic representation:

$X \quad O_1$

O_1

Within-Subjects Quasi-Experiments

- **One-group pretest–posttest designs** typically yield extremely weak evidence of causal relationships.
  - Symbolic representation:

    O_1 X O_2
- **Time-series designs** gather preintervention and postintervention data over a longer period.
  - Symbolic representation:

    O_1 O_2 O_3 O_4 X O_5 O_6 O_7 O_8

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Advantages and Disadvantages of Quasi-Experiments

- May be easier and more practical than true experiments **but**
  - They make it more difficult to infer causality.
  - Usually there are several alternative **rival hypotheses** for results.

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Question

Which design is considered a quasi-experimental research design?

a. Pretest–posttest design

b. Posttest-only design

c. Crossover design

d. Within-subjects design

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Answer

d. Within-subjects design

Rationale: Quasi-experimental research designs include nonequivalent control group and within-subjects designs. The other research designs are used for experimental research.

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Nonexperimental Studies

- If researchers do not intervene by controlling independent variable, the study is nonexperimental (observational).
- Not all independent variables ("causes") of interest to nurse researchers can be experimentally manipulated.
  - For example, gender cannot ever be manipulated.
  - Smoking cannot **ethically** be manipulated.

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Types of Nonexperimental Studies

Correlational designs

- Cause-probing questions (e.g., prognosis or harm/etiology questions) for which manipulation is not possible are typically addressed with a **correlational design**.
- A **correlation** is an association between variables and can be detected through statistical analysis.
- Correlational studies are weaker than RCTs for cause-probing questions, but different designs offer varying degrees of supportive evidence.

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Types of Nonexperimental Studies—(cont.)

- In a **prospective** correlational design, a potential cause in the present (e.g., experiencing vs. not experiencing a miscarriage) is linked to a hypothesized later outcome (e.g., depression 6 months later).
- This is called a **cohort study** by medical researchers.
- Prospective designs are stronger than retrospective designs in supporting causal inferences—but neither is as strong as experimental designs.

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Retrospective Designs

- In a **retrospective** correlational design, an outcome in the present (e.g., depression) is linked to a hypothesized cause occurring in the past (e.g., having had a miscarriage).
- One retrospective design is a **case–control design** in which "cases" (e.g., those with lung cancer) are compared to "controls" (e.g., those without lung cancer) on prior potential causes (e.g., smoking habits).

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Descriptive Research

- Not all research is cause probing.
- The purpose of **descriptive** studies is to observe, describe, and document aspects of a situation.
- Some research is **descriptive** (e.g., ascertaining the prevalence of a health problem).
- Other research is **descriptive correlational**—the purpose is to describe whether variables are related, without ascribing a cause-and-effect connection.

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Advantages and Disadvantages of Nonexperimental Research

- Disadvantage: does not yield persuasive evidence for causal inferences
  - This is not a problem when the aim is description, but correlational studies are often undertaken to discover causes.
- Advantage: efficient way to collect large amounts of data when intervention and/or randomization is not possible

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Time Dimension in Research Design

- **Cross-sectional design**—Data are collected at a single point in time.
- **Longitudinal design**—Data are collected two or more times over an extended period.
  - **Follow-up studies**
- Longitudinal designs are better at showing patterns of change and at clarifying whether a cause occurred before an effect (outcome).
- A challenge in longitudinal studies is **attrition** or the loss of participants over time.

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Controlling the Study Context

- Controlling external factors (such as research context)
  - Achieving **constancy of conditions**
  - Control over environment, setting, time
  - Control over intervention via a formal protocol: **intervention fidelity**

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Controlling Participant Factors

- Randomization
  - Subjects as own controls (crossover design)
- Homogeneity (restricting sample)
- Matching
- Statistical control (e.g., **analysis of covariance**)

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Characteristics of Good Quantitative Research Design

- **Statistical conclusion validity**—the ability to detect true relationships statistically
- **Internal validity**—the extent to which it can be inferred that the independent variable caused or influenced the dependent variable
- **External validity**—the generalizability of the observed relationships across samples, settings, or time
- **Construct validity**—the degree to which key constructs are adequately captured in the study

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Question

Tell whether the following statement is True or False.

Cross-sectional research designs are helpful in showing patterns of change.

a. True

b. False

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Answer

b. False

Rationale: Longitudinal studies, in which data are collected two or more times over an extended period, are better at showing patterns of change than cross-sectional studies, which collect data at a single point in time.

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Threats to Statistical Conclusion Validity

- Low statistical power (e.g., sample too small)
- Weakly defined “cause”—independent variable not powerful
- Unreliable implementation of a treatment—low intervention fidelity

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Threats to Internal Validity

- Temporal ambiguity
- Selection threat—biases arising from preexisting differences between groups being compared
  - This is the single biggest threat to studies that do not use an experimental design.
- History threat—other events co-occurring with causal factor that could also affect outcomes
- Maturation threat—processes that result simply from the passage of time
- Mortality/attrition threat—differential loss of participants from different groups
  - Typically a threat in experimental studies

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Threats to External Validity

- Inadequate sampling of study participants
- Unfortunately, enhancing internal validity can sometimes have adverse effects on external validity.

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Threats to Construct Validity

- Is the intervention a good representation of the underlying construct?
- Is it the intervention or awareness of the intervention that resulted in benefits?
- Does the dependent variable really measure the intended constructs?

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