

Biomedical
Science

Molecular
Genetics



BMS 34010B | Fall 2026-2027

Quantitative Analysis
Quantitative Research



Free Session

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Quantitative Analysis in Biomedical Sciences

To **quantitate** means to **numerate**.

Why do numbers matter in biomedical sciences? Because every medical decision needs to be **backed by measurements**.

Blood glucose levels

→ **diabetes diagnosis**

Cholesterol levels

→ **cardiovascular risk**

Clinical trial results

→ **deciding if a new drug works**

THINKING PROMPT

Can anyone share a medical test you have heard of or taken? What number did it give you, and **why was that important?**

AND THEN

How do you think these numbers were **made meaningful?**



What Is a Scientific Method?

The scientific method is a systematic process ensuring **reliable, reproducible results.**

Because every **knowledge** must be **based upon facts.**

The Scientific Method is a **problem resolving method** that has characterized natural science since the **17th century**. It is a method of **investigation**, in which the scientist must follow **ordered and compulsory steps** designed to resolve problems, answer questions and standardize observations.

THE PROCESS OF

- 1 Making **observations** of the world
- 2 Proposing **ideas** about how something works
- 3 **Testing** those ideas, and discarding (or modifying) our ideas in response to the test results

... is the **essence of the scientific method.**



Steps of the Scientific Method

1 Question (testable) – Observation

2 Perform background research

3 Formulate a hypothesis

4 Conduct experiment

5 Analyze data / result

False hypothesis

back to the hypothesis

True hypothesis

on to the conclusion

Report conclusion



Steps 1–3: Question, Research, Hypothesis

Step 1. Ask a question

Identify a **problem or observation**.

Example: Why do some patients with the same infection recover faster than others?

Step 2. Do background research

Review **existing literature, clinical reports, or lab records**.

Example: Previous studies show variations may be linked to immune response.

Step 3. Form a hypothesis

Create a **testable prediction**.

Example: Patients with higher white blood cell counts recover faster.



Step 4: Experiment — Test the Hypothesis

Design a **controlled study** to collect data.

Example: Measure WBC counts in **100 patients** and track recovery times.

WHAT THE DESIGN MUST INCLUDE

- 1 Develop and follow a **procedure**, and include a detailed **materials list**.
- 2 Choose the **independent (manipulated) variable** — there must be just **ONE**.
- 3 Choose the **dependent (responding) variable** to measure.
- 4 A **controlled experiment** must be designed for each experiment — exposed to the same conditions and parameters.
- 5 The outcome must be **measurable**.
- 6 The experimentation must be **repeated several times** — more trials, more statistically supported result.



Steps 5–7: Analyze, Conclude, Communicate

Step 5. Collect & analyze data

Use **statistics** to detect patterns and test significance.

Example: Compare average recovery times between groups with high vs. low WBC counts.

Step 6. Draw conclusions

Accept, reject, or refine the hypothesis.

Example: Data shows high WBC counts correlate with faster recovery → **hypothesis supported.**

Step 7. Communicate results

Share findings through **reports, publications, or presentations.**

Example: Publish results in a clinical journal so others can **replicate and apply them.**



Work Through the Scientific Process

Example 1

New medication for diabetes.

Question:

Research:

Hypothesis:

Experiment:

Collect data & analyze:

Example 2

Living with diabetes — lifestyle and emotional wellbeing.

Question:

Research:

Hypothesis:

Experiment:

Collect data & analyze:

What did you notice about the **type of data** collected in example 1 and example 2?

Quantitative Data

Qualitative Data



Two Main Types of Research Method

1. Qualitative Research

A systematic approach that seeks to understand **experiences, perceptions, behaviors, or social phenomena** through **non-numerical data** such as words, images, or observations. It aims to explore **meaning, context, and complexity** rather than quantify outcomes.

FEATURES

- Uses tools like interviews, focus groups, or observations
- Results are expressed in patterns, narratives, or conceptual models

2. Quantitative Research

A systematic investigation that **measures variables numerically** and analyzes data using **statistical, mathematical, or computational techniques**. It seeks to quantify relationships, patterns, or differences in a way that can be **generalized to a larger population**.

FEATURES

- Uses structured tools like surveys, experiments, or laboratory measurements
- Results are expressed in numbers, percentages, or statistical values
- Often tests hypotheses or predicts outcomes

QUANTITATIVE RESEARCH



DATA
NUMERICAL

PURPOSE
MEASURE, QUANTIFY,
TEST HYPOTHESES

METHOD
SURVEYS, EXPERIMENTS,
LAB TESTS

OUTCOME
STATISTICS. GRAPHS.

QUALITATIVE RESEARCH



DATA
NON-NUMERICAL
(TEXT, IMAGES, AUDIO)

PURPOSE
EXPLORE, UNDERSTAND,
INTERPRET

METHOD
INTERVIEWS, OBSERVATIONS,
FOCUS GROUPS



When to Do Quantitative Research

- If your study aims to find the answer to an inquiry through **numerical evidence**, then you should make use of quantitative research.
- In general, use **qualitative research at the beginning** of a design process to **uncover innovations**. Use **quantitative research at the end** of a design process to **measure improvement**.
- The main activity for which quantitative research is especially suited is the **testing of hypothesis**.



The Four Quantitative Research Designs

1. Descriptive

2. Correlational

3. Causal-Comparative / Quasi-Experimental

4. Experimental Research



Descriptive Research

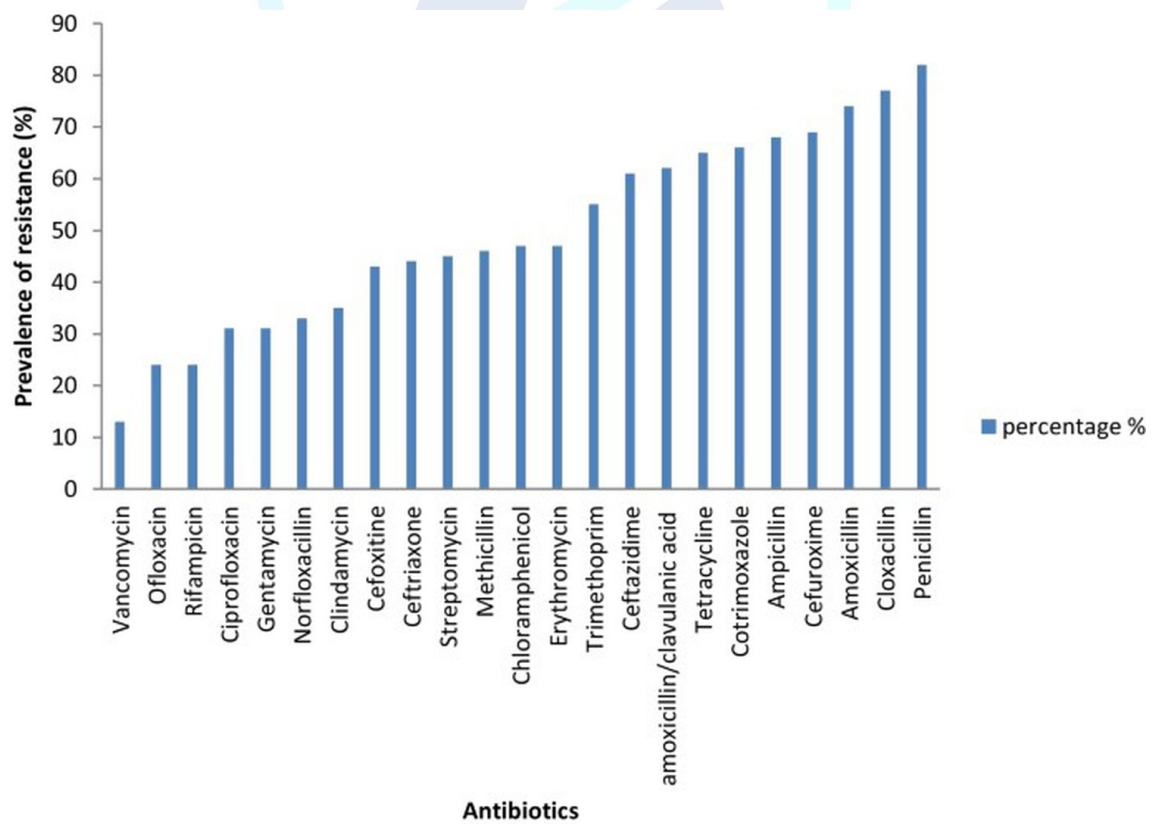
Aims to answer a question about **"What exists?"**

Example

The **prevalence of antibiotic resistance**

Tools

Surveys and lab data collection



<https://aricjournal.biomedcentral.com/articles/10.1186/s13756-023-01243-x>



Correlational Research

Aims to find **relationships** — **not causation**.

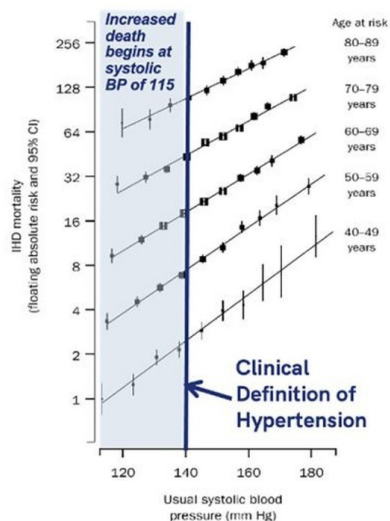
Example

High blood pressure associated with heart disease

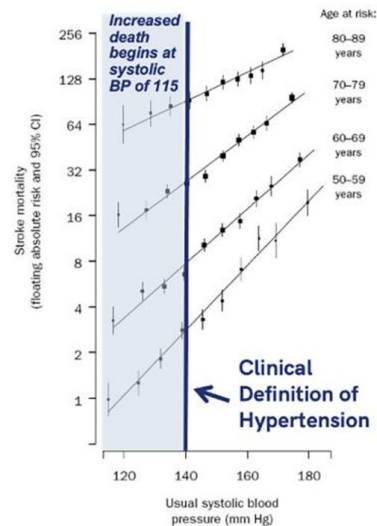
Tools

Surveys, checklists, lab data collection

Ischemic Heart Disease mortality



Stroke Mortality



<https://edition.cnn.com/2021/05/30/health/high-blood-pressure-frieden>

Correlational and descriptive designs are **observational designs** — i.e. **no intervention** is taking place during the research.



Experimental Research (True Experiment)

An experimental design where participants are **randomly assigned** into groups (e.g., treatment vs control), ensuring that differences in outcomes are due to the **intervention alone**.

Example: Randomized controlled trial of a new cholesterol drug.

THE FOUR PILLARS

1

Randomization

Every participant has an **equal chance** of being in any group. Minimizes bias; balances confounders across groups.

2

Control group

Provides a **comparison baseline**. Often receives placebo or standard care.

3

Manipulation

Researchers deliberately apply an **intervention** — e.g. a new drug or new lab method.

4

Blinding

Used to prevent bias. **Single-blind:** patient does not know group. **Double-blind:** neither patient nor researcher knows.



Worked Example: Randomized Controlled Blinded

RESEARCH QUESTION

Does using an **automated hematology analyzer** improve the accuracy and turnaround time of complete blood count (CBC) results compared to the **standard manual microscopy** method?

- 1 **Sample pool:** collect **100 blood samples** from routine clinical submissions (with patient consent & anonymization).
- 2 **Randomization:** randomly assign each sample to be tested first by **Group A — manual microscopy** or **Group B — automated analyzer**. Both groups eventually run both methods, but the order is randomized to prevent bias.
- 3 **Control / comparison:** manual method = traditional "control" standard; automated analyzer = "experimental" intervention.
- 4 **Blinding:** technologists who validate results **don't know which method was used first.**

OUTCOMES MEASURED

Accuracy

Concordance with reference laboratory results

Turnaround time

Minutes per sample

Error rate

% of samples needing re-runs or corrections



Quasi-Experimental Research

A quasi-experimental design (**quasi** means almost) looks like an experiment, but it **does not use random assignment** of participants into groups. Instead, researchers use **naturally existing groups or conditions**.

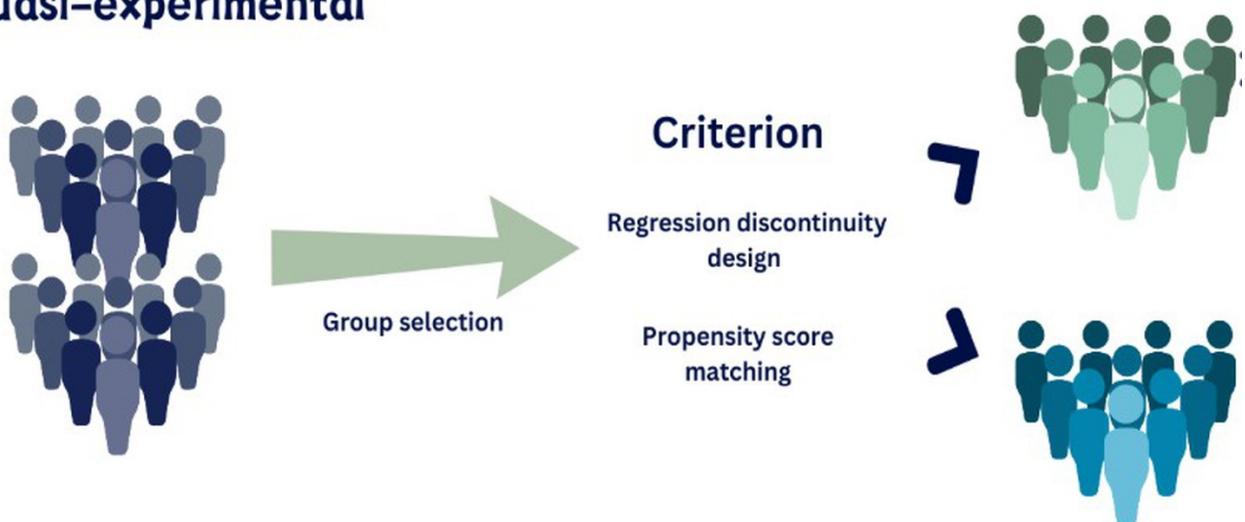
No proper control group

Therefore **matching** is used sometimes

Example

A new hospital infection control policy in one ward vs. another ward

Quasi-experimental



<https://unimelb.libguides.com/whichstudytype/QuasiExperimental>



Worked Example: Quasi-Experimental

RESEARCH QUESTION

Does an automated analyzer outperform manual microscopy in terms of **turnaround time and accuracy?**

Sample pool

100 blood samples

Group allocation

The first 50 samples this week are processed manually; the next 50 use the analyzer

No randomization: groups differ by **time of collection**, not by chance.

POTENTIAL CONFOUNDERS

Sample quality may **degrade across time**

Technician fatigue or **staffing differences** could affect results

Analysis adjustment: researchers might use **statistical matching** — e.g. adjust for sample volume or storage conditions.

Strength

Easier to run; reflects **real workflow**

Limitation

Harder to prove **causality** due to group differences



Advantages of Quantitative Research

1

Settles the hypothesis

An excellent way of finalizing results and **proving or disproving a hypothesis**. The structure has not changed for centuries, so it is standard across many scientific fields and disciplines.

2

Publishable answers

After statistical analysis, a **comprehensive answer** is reached, and the results can be legitimately discussed and published.

3

Tests qualitative findings

Useful for **testing the results** gained by a series of qualitative experiments, leading to a final answer and narrowing down directions for follow-up research.



Disadvantages of Quantitative Research

1

Costly and slow

Quantitative experiments can be **difficult and expensive**, and require a lot of **time** to perform.

2

Demanding to plan

They must be carefully planned to ensure complete **randomization** and correct designation of **control groups**.

3

Statistically heavy

Usually require **extensive statistical analysis**, which can be difficult since most scientists are not statisticians.



Characteristics of Quantitative Research

1

Structured instruments

The data is usually gathered using structured **research instruments**.

2

Larger, representative samples

The results are based on **larger sample sizes** that are representative of the population.

3

Replicable

The study can usually be **replicated or repeated**. The researcher has a clearly defined research question to which objective answers are sought.

4

Designed up front

All aspects of the study are **carefully designed before** data is collected.

5

Numerical output

Data are in the form of numbers and statistics, often arranged in **tables, charts, figures**, or other non-textual forms.

**Check Point**State **True or False**

1 Quantitative research tells the quality of some phenomena.

T / F

2 Quantitative data describes a variable.

T / F

3 Close-ended question interviews can be conducted in quantitative research.

T / F

4 Quantitative research design is an excellent way of finalizing results and proving or disproving a hypothesis.

T / F



To Summarise...

METHOD 7

Steps of the scientific method

- Question, background research, hypothesis
- Experiment, then analyze the data
- Draw conclusions, then communicate results

TYPES 2

Main research methods

- Qualitative — non-numerical, explores meaning
- Quantitative — numerical, tests hypotheses
- Qualitative first to uncover, quantitative to measure

DESIGNS 4

Quantitative research designs

- Descriptive — what exists?
- Correlational — relationships, not causation
- Quasi-experimental and true experimental

OBSERVE 2

Observational designs

- Descriptive and correlational
- No intervention takes place during the research
- Tools: surveys, checklists, lab data collection

RCT 4

Pillars of a true experiment

- Randomization — equal chance of any group
- Control group and deliberate manipulation
- Blinding — single or double

QUASI 0

Randomization in quasi-designs

- Uses naturally existing groups or conditions
- Matching used where no control group exists
- Easier to run, harder to prove causality

THE THREAD THROUGH THE LECTURE

Every medical decision needs to be **backed by measurements** — and the main activity for which quantitative research is especially suited is the **testing of hypothesis**.