Biostatistics

Luonan Chen

Chinese Academy of Sciences

Lecture 1

Introduction To Biostatistics

- ***Key words :***
  - *Statistics(统计), data（数据）, Biostatistics（生物统计）,*
  - *Variable （变量）,Population（总体）,Sample（样本）*

- 样本：从总体中抽出若干个个体的集合称为样本。
- 变量：相同性质的事物间表现差异性或差异特征的数据称为变量。
- 参数：参数也称参量，是对一个总体特征的度量。
- 准确性：是指统计数接近真知的程度。
- 精确性：指调查或试验中同一试验指标或性状的重复观测值彼此接近程度的大小。
- 误差：是试验中不可控因素所引起的观测值偏离真值的差异
- 错误：是指在试验过程中，人为因素所引起的差错。
- 统计数：从样本计算所得的数值称为统计数，它是总体参数的估计值。
- 总体：研究对象的全体，是具有相同性质的个体所组成的集合
- 个体：组成总体的基本单元
- 生物统计学：是统计学在生物学中的应用，是用数理统计的原理和方法来分析解释生命现象的一门科学，是研究生命过程中以样本推断总体的一门科学。

Statistics

- The field of statistics: The study and use of theory and methods for the analysis of data arising from random processes or phenomena. The study of how we make sense of data.

_ forming hypotheses
_ designing experiments and observational studies
_ gathering data
_ summarizing data
_ drawing inferences from data, e.g. testing hypotheses

Biostatistics

- Biostatistics is the branch of applied statistics directed toward applications in the health sciences and biology
- Biostatistics is sometimes distinguished from the field of biometry based upon whether applications are in the health sciences (biostatistics) or in broader biology (biometry, e.g., agriculture, ecology, wildlife biology).

Difference: Statistics and Biostatistics

The tools of statistics are employed in many fields:

business, education, psychology, agriculture, economics, …, etc.

When the data analyzed are derived from the biological science and medicine,

we use the term biostatistics to distinguish this particular application of statistical tools and concepts.

Statistics → Basis

- Bioinformatics
- Big-data science
- Systems biology
- Computational biology
- Network biology

Another aspect: Dynamics

Biostatistician Roles

- Identify and develop treatments for disease and estimate their effects, identify risk factors for diseases.
- Design, monitor, analyze, interpret, and report results of biological studies.
- Develop statistical methodologies to address questions arising from medical/biological data.
- Provide the hypothesis on the mechanisms

Challenge

- Much of life is composed of a systematic component (i.e., signal) and a random component (i.e., error or noise)

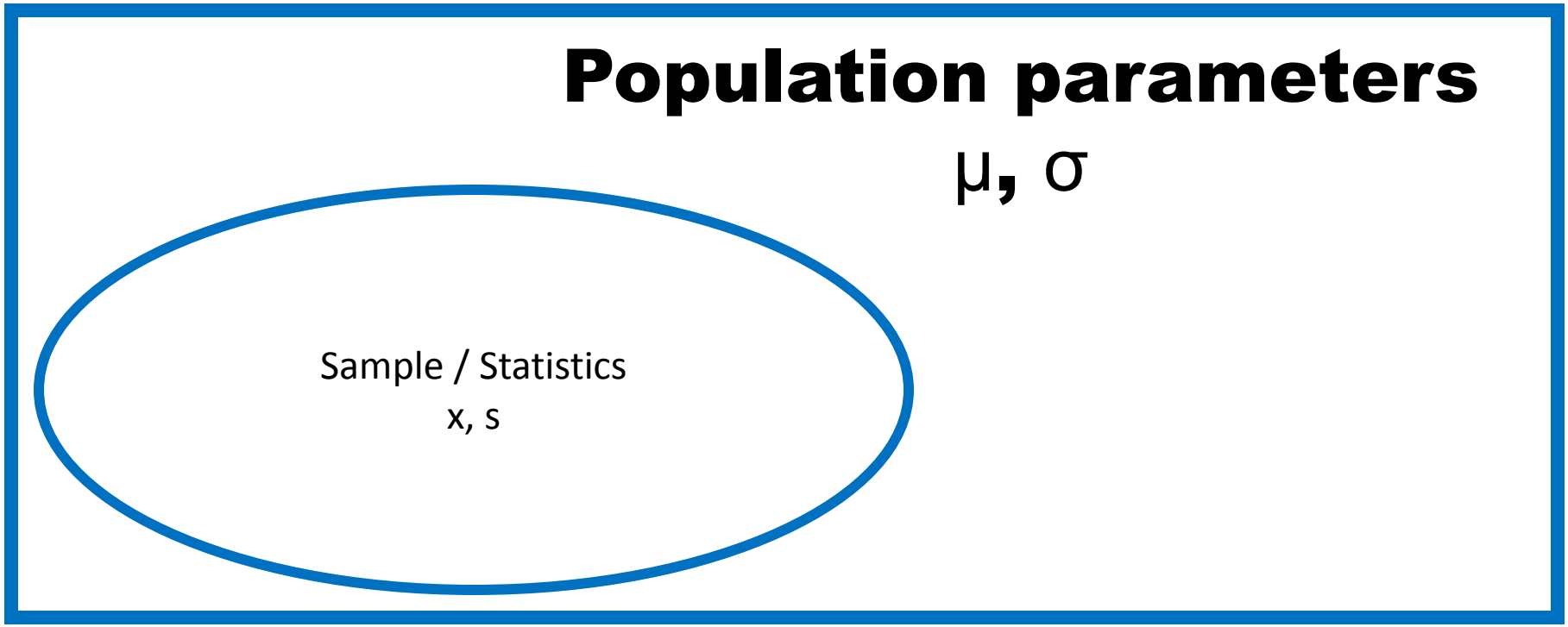
  Real data = Deterministic + Random

- Example:
  - Smoking is associated with lung cancer.
  - Yet not everyone that smokes, gets lung cancer, and not everyone that gets lung cancer, smokes
  - Yet we know that there is an association (a systematic component)

- Our challenge
  - Identify the systematic component (separate it from the random component), estimate it, and perhaps make inferences with it

Big Picture

Populations and Samples



Data:

- **The raw material of Statistics is data.**
- **We may define data as figures. Figures result from the process of counting or from taking a measurement.**
- ***For example:***
- **- When a hospital administrator counts the number of patients (counting).**
- **- When a nurse weighs a patient (measurement)**
- **- Gene sequences**
- **- Gene expression**
- **- Protein expression**
- **- metabolic expression**
- **- molecular interaction**

* Sources of Data:

We search for suitable data to serve as the raw material for our investigation.

Such data are available from one or more of the following sources:

1- Routinely kept records.

For example:

- Hospital medical records contain immense amounts of information on patients.
- Hospital accounting records contain a wealth of data on the facility's business activities.

2- External sources.

The data needed to answer a question may already exist in the form of

published reports, commercially available data banks, or the research literature.

3- Surveys:

The source may be a survey, if the data needed is about answering certain questions.

For example:

If the administrator of a clinic wishes to obtain information regarding the mode of transportation used by patients to visit the clinic,

then a survey may be conducted among patients to obtain this information.

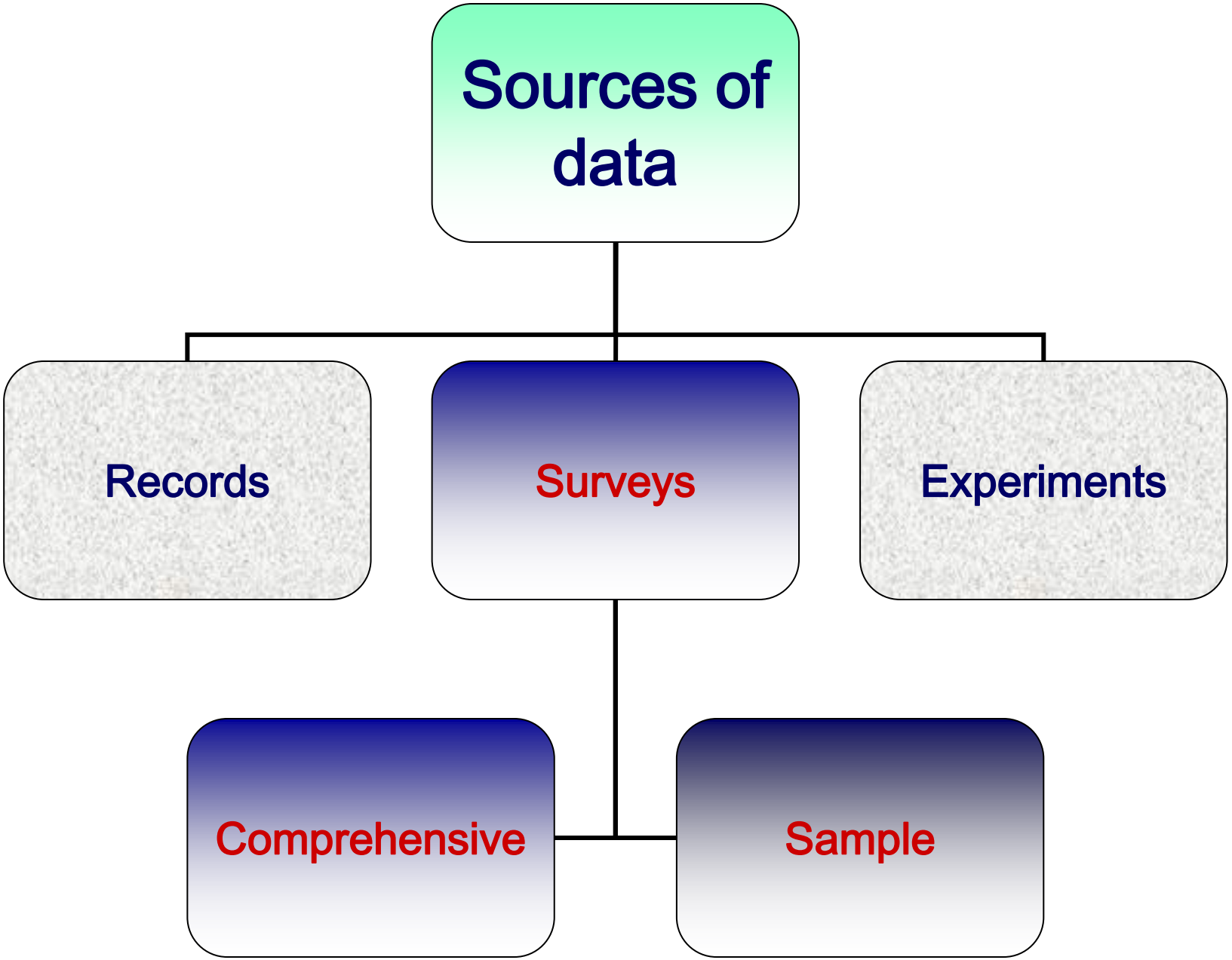
4- Experiments.

Frequently the data needed to answer a question are available only as the result of an experiment.

For example:

If one wishes to know which of several drug is best for treating a disease,

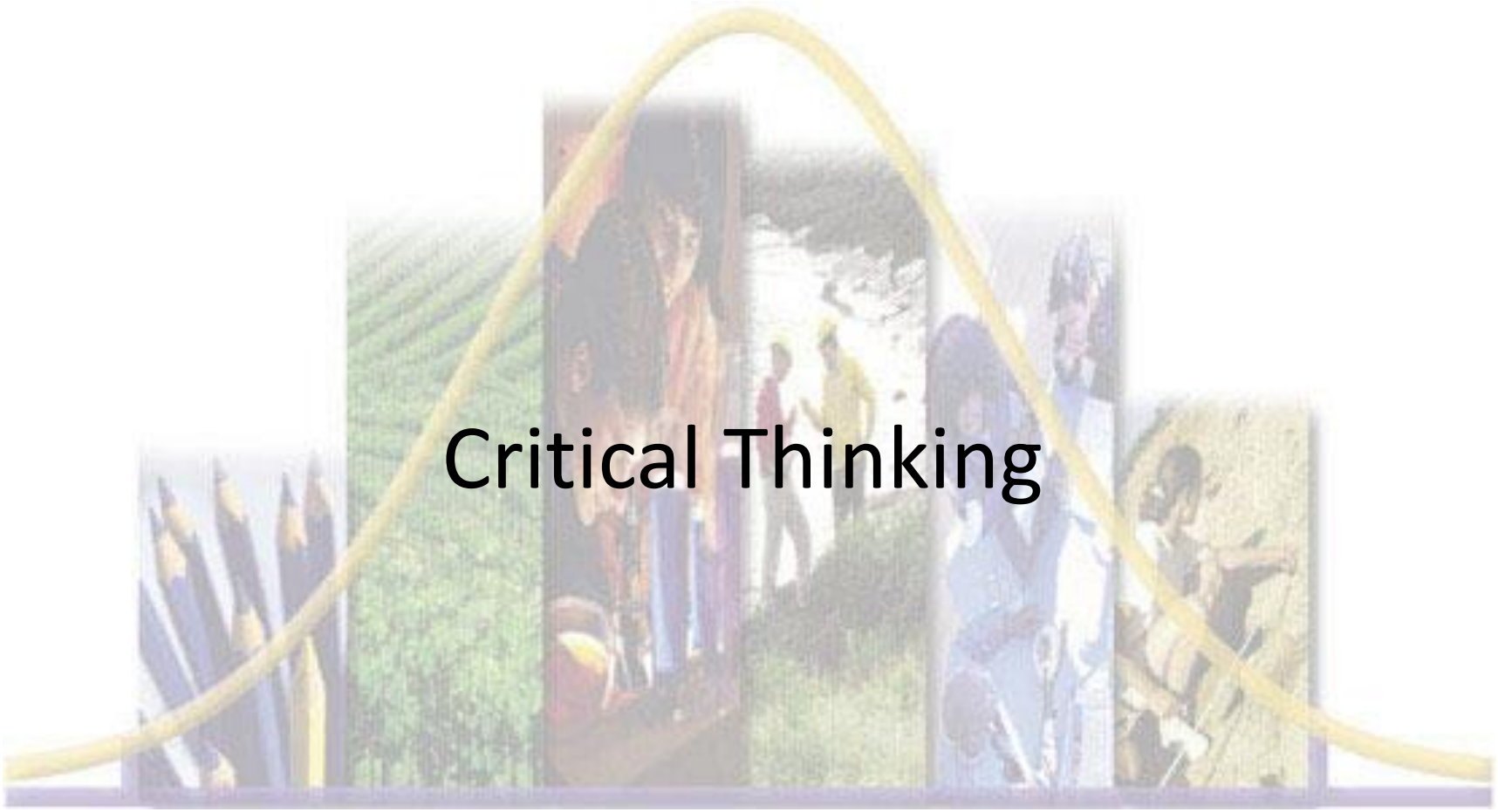
he might conduct an experiment on several groups of mice in which mice each group are given different drug.


Sources of data
Records
Surveys
Experiments
Comprehensive
Sample

Data

- Pieces of information : Information resolves uncertainty

- Scales of Measurement
  - Nominal – unordered categories
  - Ordinal – ordered categories
  - Discrete – only whole numbers are possible, order and magnitude matters
  - Continuous – any value is conceivable



Critical Thinking

Success in Statistics

- Success in the introductory statistics typically requires more common sense than mathematical expertise.

How common sense is used when we think critically about data and statistics ?

Misuses of Statistics

Voluntary response sample

(or self-selected survey)

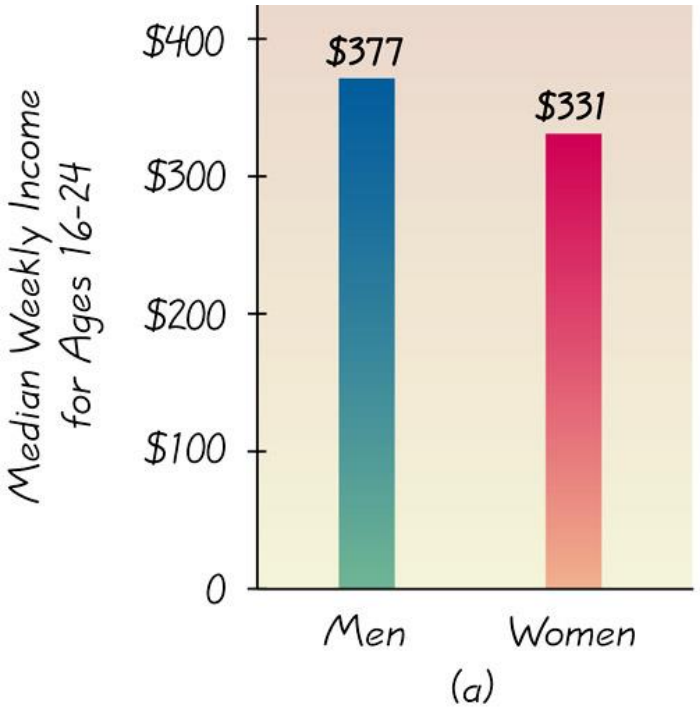
one in which the respondents themselves decide whether to be included.

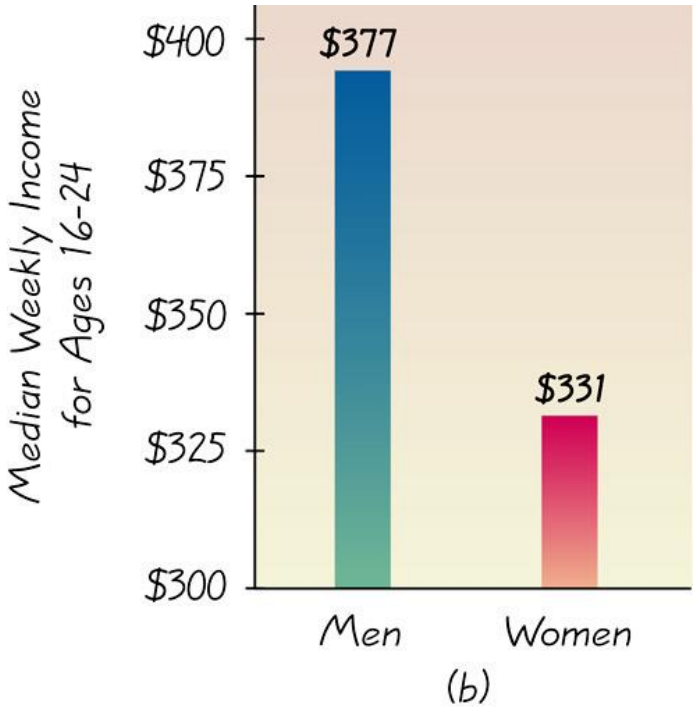
In this case, valid conclusions can be made only about the specific group of people who agree to participate.

Misuses of Statistics

- Small Samples

Misleading Graphs





❖ Pictographs

Double the length, width, and height of a cube, and the volume increases by a factor of eight

Not 2 fold but 8 fold

Misuses of Statistics

- Bad Samples
- Small Samples
- Misleading Graphs
- Pictographs
- Distorted Percentages
- Loaded Questions
- Order of Questions
- Refusals
- Correlation & Causality
- Self Interest Study
- Precise Numbers
- Partial Pictures
- Deliberate Distortions

To correctly interpret a graph, we should analyze the numerical information given in the graph instead of being mislead by its general shape.

* A variable:

It is a characteristic that takes on different values in different persons, places, or things.

For example:

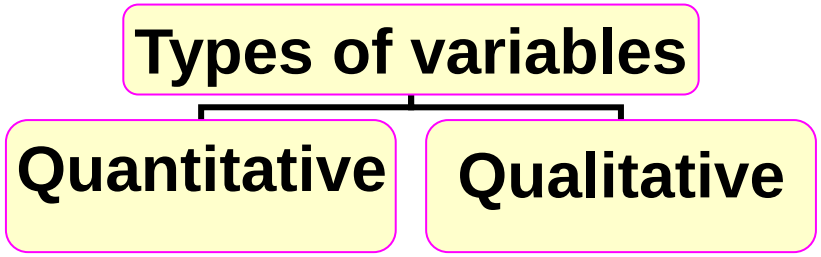
- heart rate,

- the heights of adult males,

- the weights of preschool children,

- the ages of patients seen in a dental clinic,

- the concentration of a protein.



Quantitative Variables

It can be measured in the usual sense.

For example:

- **the heights of adult males,**
- **the weights of preschool children,**
- **the ages of patients seen in a**
- **dental clinic.**

Qualitative Variables

Many characteristics are not capable of being measured. Some of them can be ordered or ranked.

For example:

- **classification of people into socio-economic groups,**
- **social classes based on income, education, etc.**

Types of quantitative variables

- Discrete
- Continuous

A discrete variable

is characterized by gaps or interruptions in the values that it can assume.

For example:

- The number of daily admissions to a general hospital,
- The number of decayed, missing or filled teeth per child in an elementary school.

A continuous variable

can assume any value within a specified relevant interval of values assumed by the variable.

For example:

- Height,
- weight,
- skull circumference.

No matter how close together the observed heights of two people, we can find another person whose height falls somewhere in between.

* A population:

It is the largest collection of values of a random variable for which we have an interest at a particular time.

For example:

The weights of all the children enrolled in a certain elementary school.

Populations may be finite or infinite.

* A sample:

It is a part of a population.

For example:

The weights of only a fraction of these children.

Key Concepts

- Sample data must be collected in an appropriate way, such as through a process of random selection.

An example for generating data

- Example: To assess whether or not saccharine (糖精) is carcinogenic, a researcher feeds 25 mice daily doses of saccharine. After 2 months, 10 of the mice have developed tumors.

By definition, this is an experiment, but not a very good one. In the saccharine example, we do not know whether 10/25 with tumors is high because there is no control group to which comparison can be made.

1. Solution: then, select another 25 mice and treat them exactly the same but give them daily doses of an inert substance (a placebo). Suppose that in the control group only 1 mouse develops a tumor. Is this evidence of a carcinogenic effect? Maybe, but there is still a problem.

- What if the mice in the 2 groups differ systematically, E.g., group 1 from genetic strain 1, group 2 from genetic strain 2 ?

Here, we do not know whether saccharine is carcinogenic, or if genetic strain 1 is simply more susceptible to tumors.

- We say that the effects of genetic strain and saccharine are confounded (mixed up)

2. Solution: Starting with 50 relatively homogeneous mice, randomly assign 25 to the saccharine treatment, and 25 to the control treatment.

3. Randomization : an extremely important aspect of experimental design .

4. Another important concept, especially in human experimentation, is blinding.

Major Points

- If sample data are not collected in an appropriate way, the data may be so completely useless that no amount of statistical tutoring can salvage them.

- Randomness typically plays a critical role in determining which data to collect.

Definitions

- Cross Sectional Study

  Data are observed, measured, and collected at one point in time.

- Retrospective (or Case Control) Study

  Data are collected from the past by going back in time.

- Prospective (or Longitudinal or Cohort) Study

  Data are collected in the future from groups (called cohorts) sharing common factors.

Definitions

- **Confounding**

  occurs in an experiment when the experimenter is not able to distinguish between the effects of different factors

Try to plan the experiment so confounding does not occur!

Controlling Effects of Variables

- Blinding

  subject does not know he or she is receiving a treatment or placebo （安慰药）

- Blocks

  groups of subjects with similar characteristics

- Completely Randomized Experimental Design

  subjects are put into blocks through a process of random selection

- Rigorously Controlled Design

  subjects are very carefully chosen

Replication and Sample Size

Replication

repetition of an experiment when there are enough subjects to recognize the differences in different treatments

Sample Size

use a sample size that is large enough to see the true nature of any effects and obtain that sample using an appropriate method, such as one based on randomness

Definitions

Random Sample

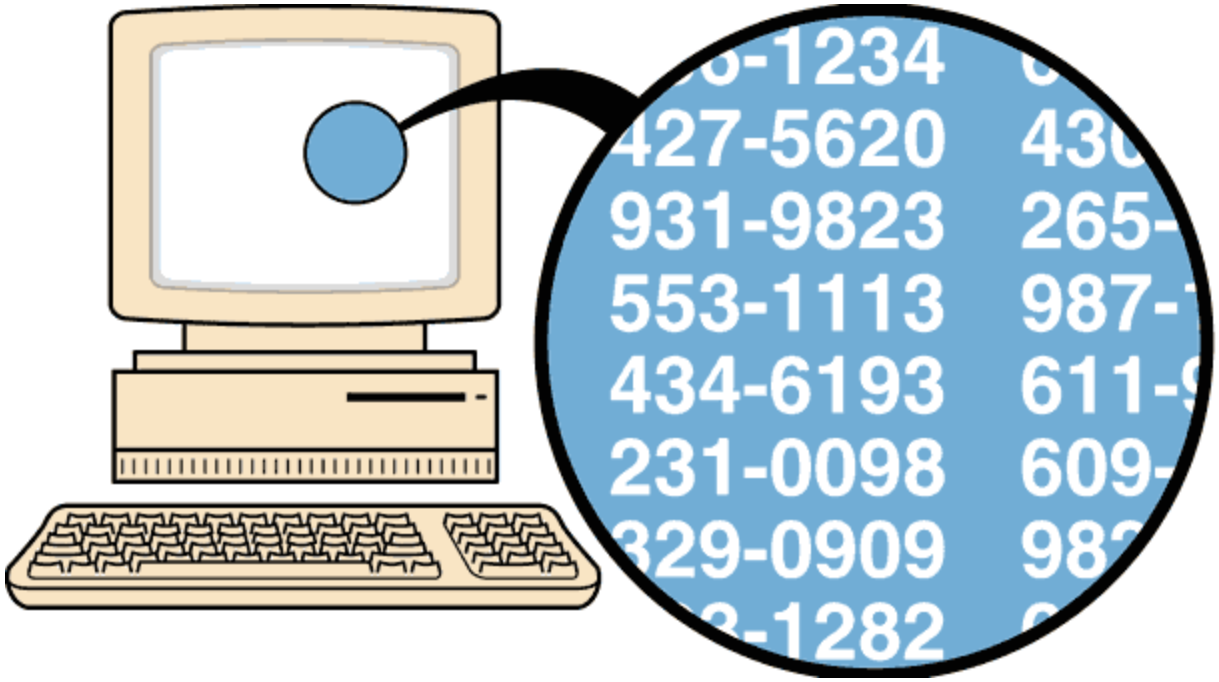
members of the population are selected in such a way that each individual member has an equal chance of being selected

Simple Random Sample (of size n)

subjects selected in such a way that every possible sample of the same size n has the same chance of being chosen

Random Sampling

selection so that each has an
equal chance of being selected

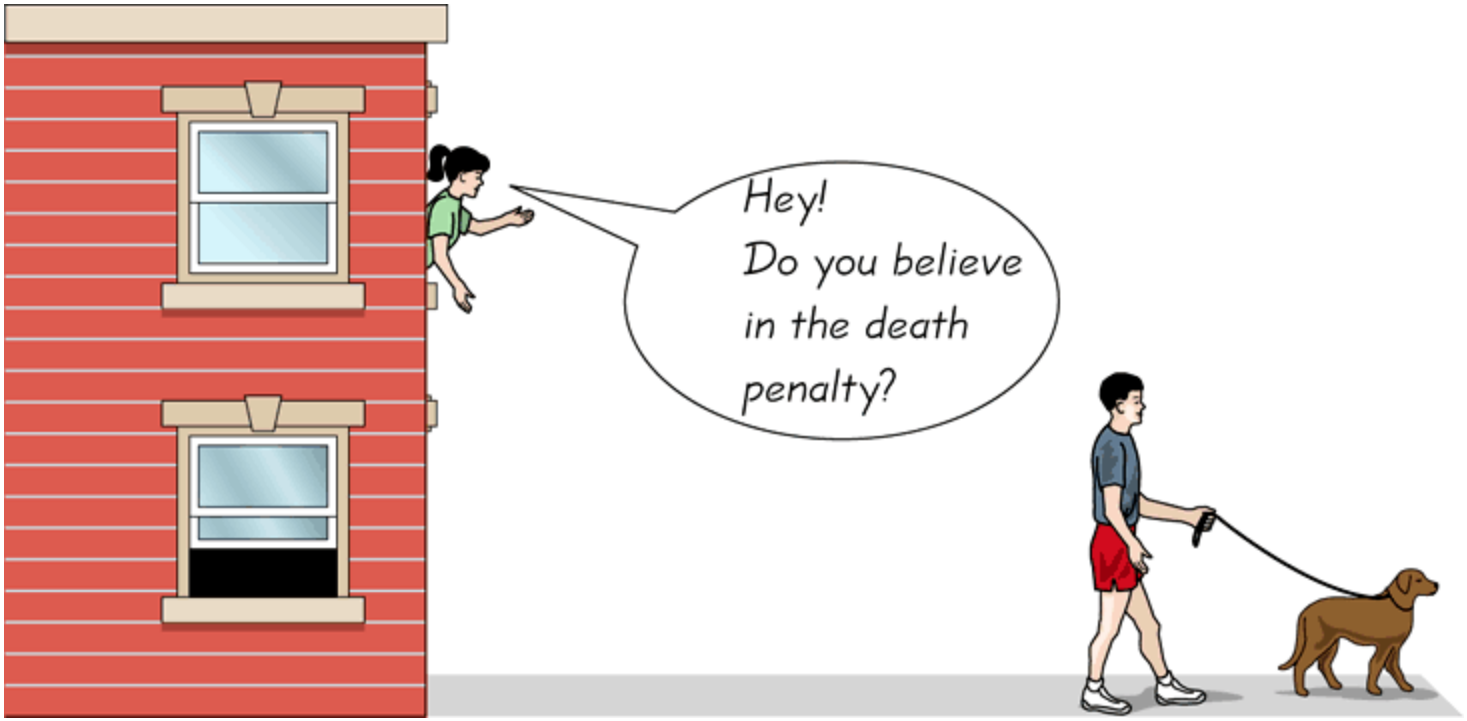


Systematic Sampling

Select some starting point and then
select every K th element in the population

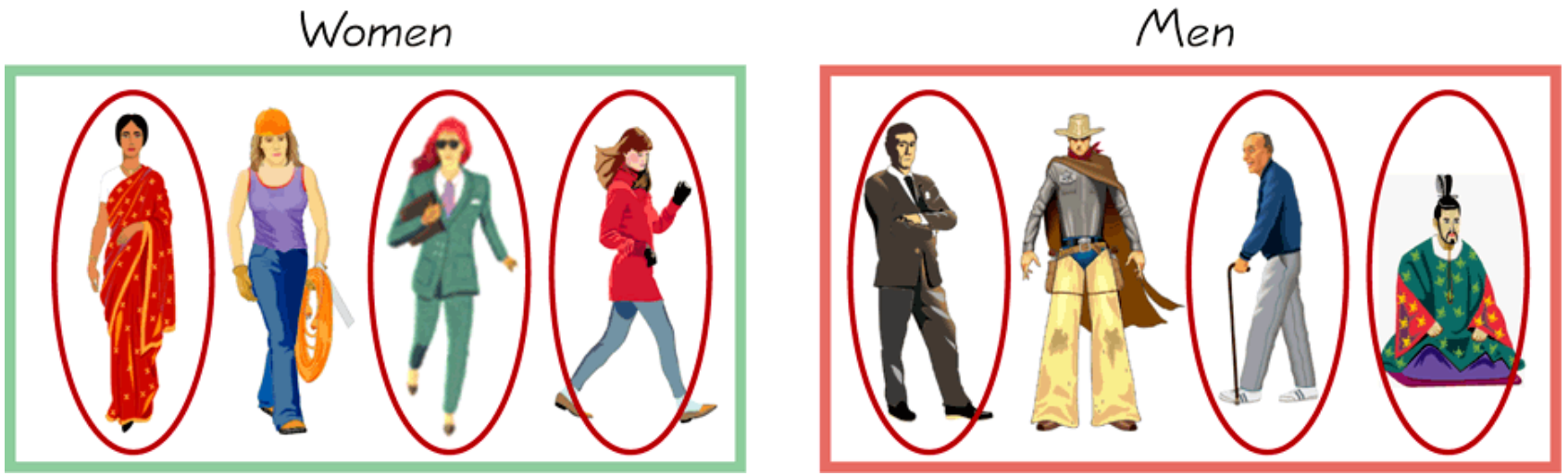
Convenience Sampling

use results that are easy to get



Stratified Sampling

subdivide the population into at least two different subgroups that share the same characteristics, then draw a sample from each subgroup (or stratum)



Methods of Sampling

- Random
- Systematic
- Convenience
- Stratified
- Cluster

Definitions

- **Sampling Error**

  the difference between a sample result and the true population result; such an error results from chance sample fluctuations

- **Nonsampling Error**

  sample data that are incorrectly collected, recorded, or analyzed (such as by selecting a biased sample, using a defective instrument, or copying the data incorrectly)