3.2 Design of Experiments

A closer look.

A few comments on this section:

- Know the definitions! Be careful, some definitions are given within examples (e.g. placebo and placebo effect).
- Response is just an important as treatment, factor and level
- Why do we run comparative experiments?
- How does randomization help control bias?
- Don’t worry too much about the random digit table.
- Understanding statistical significance is very important.

More Definitions

- Experimental Units: Individuals or items on which the experiment is performed (special case -> humans = subjects).

Response Variable, Factors, Levels, and Treatments

Response variable: The characteristic of the experimental outcome that is to be measured or observed.

Factor: A variable whose effect on the response variable is of interest in the experiment.

Levels: The possible values of a factor.

Treatment: Each experimental condition. For one-factor experiments, the treatments are the levels of the single factor. For multifactor experiments, each treatment is a combination of levels of the factors.

Recall: Observational Study vs. Experiment

- Observational Study: Passive, note characteristics and record data without any intervention
- Experiment: Active, you change a variable, control the others, and observe what happens because of the change (“impose a treatment”)

Benefits of Designed Experiments over Observational Studies

- Well designed can yield evidence for cause-effect relationships.
- Allows for the study of effects on factors that are of particular interest
- Allows for the control of factors not of interest
- Allows for the study of combined effects of several factors simultaneously, and of interactions among the factors.

Dangers in Experimental Design

- Placebo Effect: Many patients respond favorably to any treatment – even a placebo. A placebo is a dummy treatment.
- Bias: The design of a study is biased if it systematically favors certain outcomes.

Statistical Significance

- An observed effect so large that it would rarely occur by chance is called statistically significant.

Comparative Experiments

- Two or more treatments are applied to the set of experimental units. The responses of experimental units having different treatments compared.

Comment on Comparative Experiments

- Comparative Experiments are more successful than uncontrolled (that is, no comparison group) or observational studies.
- Reduce the possibility of *confounding* treatment effects.

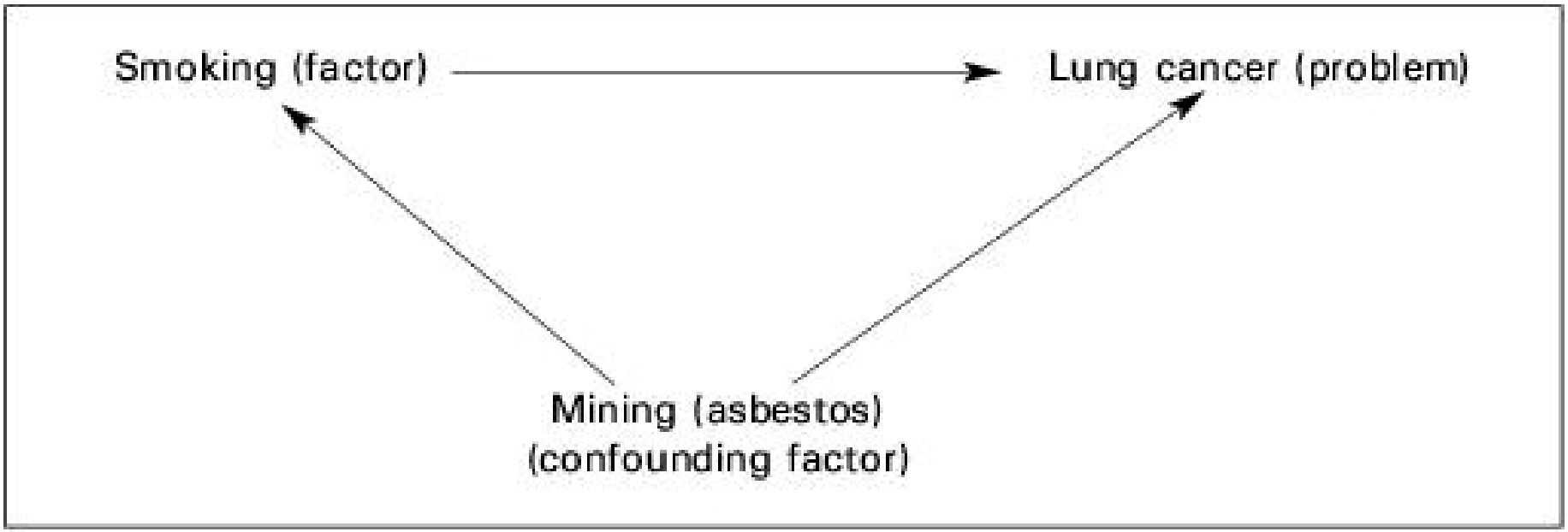
Example

- Determine the effectiveness of AZT in treating AIDS.
  - Have 100 people with advanced AIDS.
  - Randomly assign 50 to experimental group, 50 to control group.
  - Experimental group gets AZT, control group gets a placebo.
  - Compare the survival rates.

Confounding Variable

- Confounding Variable is one whose effect on the response variable cannot be separated from the effect of the explanatory variable.

Confounding Variable



Two Common (but Weak) Design Formats

1. Apply treatment, observe response

2. Take an initial observation, apply treatment, take a final observation

Comments on the Two Common (but Weak) Design Formats

1. Apply treatment, observe responses
2. Take an initial observation, apply treatment, take a final observation

The two design formats are NOT comparative experiments because there is only one treatment applied to the experimental units.

Principles of Experimental Design

- Control other variables not of primary interest.
- Use randomization to avoid selection bias and make the groups as similar as possible.
- Replication ensures similar groups and increases the chances of detecting true differences among treatments.

Control: A Closer Look

- Control the effects of factors that are not of interest. (e.g. lurking variables)
  - A Placebo Effect is a response to a dummy treatment. A group of subjects given a placebo or not treatment is called a control group. The responses of units in the treatment groups are compared to the responses of units in the control group.
  - An experimental design is biased if it systematically favors certain outcomes.

Random Assignment: A closer look

- Random Assignment is the process of randomly assigning experimental units (subjects) to treatments to create treatment groups that are similar (except for chance variation) before treatments are applied.
  - Note: It is the experimental units that are randomly assigned
  - Random assignment reduces the chances of systematic differences and reduces the chances of confounding the treatment effects

Random Assignments, contd

- When an observed difference in treatment effects is too large to reasonably have occurred by chance, we say that the difference is statistically significant.
- If significant differences among treatments are found after running a comparative randomized experiment, we conclude that the differences are CAUSED by the treatments.
- A mechanism is required to perform the process of randomization. E.g. table of random numbers, or a computerized number generator.

Replication: A closer look

- The process of repeating some or all treatments on additional experimental units.
- Replication can reduce the effects of chance variation. This will make the experiment more sensitive for detecting systematic effects of the treatment.

Cautions about Experimentation

- A hidden bias is a bias that occurs because of the way the experiment was conducted (despite the use of comparison and randomization)
- A double blind experiment is an experiment where neither the subjects nor the evaluators know which treatment a subject received. This can prevent hidden bias. Note, though, that at least one member of the research team must know which treatment each subject received. Otherwise, the data cannot be analyzed for evidence of treatment effects.

Cautions about Experimentation, contd

- Another potential weakness of an experiment can be the lack of realism. This occurs when the experiment results do not reflect what happens in situations wider in scope that the experiment.

Types of Experimental Designs

- Completely Randomized Design: the experimental units are randomly assigned to the treatments

Types of Experimental Designs

- A **block** is a group of experimental units or subjects that are known (or suspected) to be similar before the experiment is run, and therefore are expected to respond similarly after receiving a treatment.
- In a **block design**, randomization occurs by randomly assigning experimental units to treatments within each block

Types of Experimental Designs

- A matched pairs design is a block design in which there are only two observations per block.

Ex: Matched Pair Design

- Compare the IQ's of 1^{st} borns to 2^{nd} born.
- Population of N pairs of siblings.

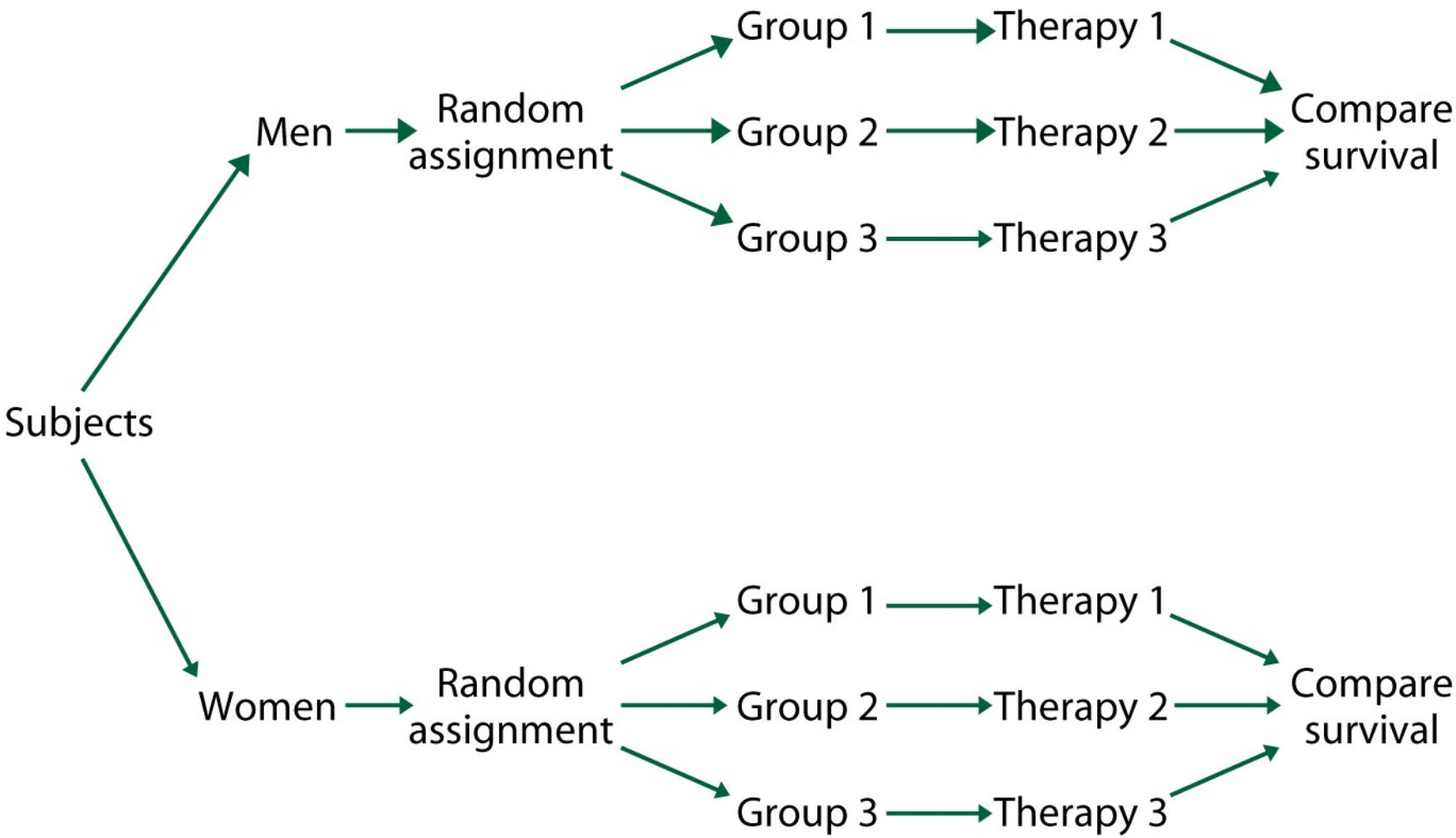
Note on blocks:

- Blocks are another form of control because effects of outside variables are controlled by bringing units with common outside characteristics into a block.

Example: Blocking

Cancer treatment

- Divide subjects into men and women.
- Randomly assign each block to three groups.
- The three groups each receive only onetreatment.
- Compare survival rates.


Subjects
Men
Random assignment
Group 1
Therapy 1
Group 2
Therapy 2
Group 3
Therapy 3
Compare survival
Women
Random assignment
Group 1
Therapy 1
Group 2
Therapy 2
Group 3
Therapy 3
Compare survival