# Math 140
# Introductory Statistics

# Last time: Sample bias

Size bias: Larger units are more likely to be included.

Voluntary Response Bias: Those who care about the issue respond.

Convenience Sample Bias: Units are chosen because of convenience.

Judgment Sample Bias: Units are chosen according to the judgment of someone (expert)

An Unbiased Sample Method requires that all units in the population have a chance of being in the sample.
A Sampling frame is the list of units you use to create the sample

# Experiments and interference about cause

We want to learn how to collect data so that
Our sample is REPRESENTATIVE of the entire population.

That is, we want to make sure the conclusions we make from a small subset of our population are applicable to the entire population.

We learned how to identify some causes of bias.

# Cause and effect

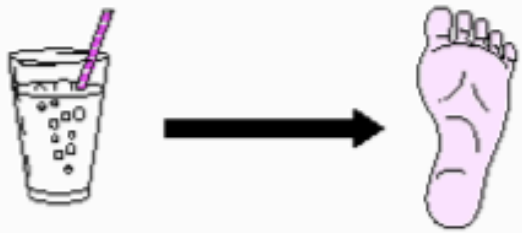
Now we want to ask : what caused the patterns we see in data?

Example: data shows kids who drink more milk have bigger feet.

Why?

Three possibilities

# Cause and effect

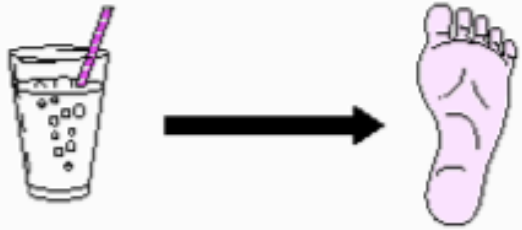


1. Drinking more milk causes children's feet to be bigger.

2. Having bigger feet causes children to drink more milk.

3. A lurking variable is responsible for both.

# In case you are wondering



1. Drinking more milk causes children's feet to be bigger.

2. Having bigger feet causes children to drink more milk.

3. A lurking variable is responsible for both.

It is the child's overall size.
Big kids drink more milk and have bigger feet

# But suppose we don't know this

We should design an experiment!

Your suggestions?

# But suppose we don't know this

We should design an experiment!

Take kids, randomly divide them
into milk-drinkers and milk-non drinkers

Follow them and study their feet growth!

This is the only way to establish cause and effect.

# Another question

Does storing coffee beans in freezer cause them to stay fresh longer than storing them at room temperature?

We are trying to establish cause and effect
by comparing two or more conditions
(store in freezer/store at room temperature)
These are called treatments

We are using experimental units (the beans)
If these are people they are called subjects

The outcome variable is called response (measure of freshness)

Subjects (or experimental units) must be randomly assigned to their treatments. These are called randomized experiments.

# A real experiment - Kelly's hamsters

Assumptions - known facts:

1) Golden Hamsters hibernate.

2) Hamsters rely on the amount of daylight to trigger hibernation.

3) An animal's capacity to transmit nerve impulses depends in part on an enzyme called Na +K+ATP-ase.

Question: If you reduce the amount of light a hamster gets, from 16 hours to 8 hours per day, what happens to the concentration of Na+K+ATP-ase?

# A real experiment - Kelly's hamsters

Experiment:

Subjects: Eight golden hamsters.

Treatments: Raised in long days (16 hours)
or short days (8 hours) of daylight.

Random Assignment of Treatments:
Kelly randomly assigned four of the hamsters to short days,
and four to long days.

Replication: Each treatment was given to four hamsters.

Response Variable: Enzyme concentration.

# A real experiment - Kelly's hamsters

Results:
Enzyme concentrations in milligrams per milliliter

## Enzyme concentration

| | | | | |
|---|---|---|---|---|
| ***Short Days*** | 12.500 | 11.625 | 18.275 | 13.225 |
| ***Long Days*** | 6.625 | 10.375 | 9.900 | 8.800 |

# A real experiment - Kelly's hamsters

Kelly: I claim the observed difference in enzyme concentrations between the two groups is due to the difference in daylight.

Skeptic: Wait a minute. As you can see, the concentration varies from one hamster to another. Some just naturally have higher concentrations. If you happened to assign all the high-enzyme hamsters to the group that got short days, you'd get results like the ones you got.

Kelly: I agree, and I was concerned about that possibility. In fact, that's precisely why I assigned day lengths to hamsters by using random numbers. The random assignment makes it extremely unlikely that all the high-enzyme hamsters would get assigned to the same group.

# A real experiment - Kelly's hamsters

How many hamsters? 8
How many in each group? 4
How many ways of choosing 4 units from 8 possibilities?
Remember?

Kelly has shown that hamsters raised in less daylight have higher hormone concentration than hamsters raised with more daylight.

In order for Kelly to show that less daylight causes an increase in the hormone concentration, she must convince us that there is no other explanation.

Has she done that?

# A real experiment - Kelly's hamsters

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How many in each group? 4
How many ways of choosing 4 units from 8 possibilities?
Remember?

$$\binom{8}{4}$$

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# Confounding

Confounded: mixed-up, confused, at a dead end.

Two possible influences on an observed outcome are said to be confounded if they are mixed together in a way that makes it impossible to separate their effects.

Confounding makes it impossible to say which explanations cause the observed response

Example: SAT scores improved when people volunteered to take an SAT preparation class. But who will volunteer? Perhaps just students that are the most motivated.

# Confounding

Many infants are dying of what seem to be respiratory obstructions.

We begin to do autopsies on infants who die with respiratory symptoms.

The infants all have thymus glands that look too big in comparison to body size.

Aha!

That must be it: The respiratory problems are caused by an enlarged thymus.

# Confounding

It became quite common in the early 1900s for surgeons to treat respiratory problems in children by removing the "enlarged" thymus. Dr. Charles Mayo of the Mayo clinic recommended this.

A third of the children who were operated on died.

| | | age | |
|---|---|---|---|
| | | Child | Adult |
| thymus size | Large | Problems | No evidence |
| | Small | No evidence | No problems |

# Confounding

But: the thymus actually gets smaller when people grow up!

It was a worthless and dangerous procedure.
Age and size were confounded.

| thymus size \ age | Child | Adult |
|---|---|---|
| Large | Problems | No evidence |
| Small | No evidence | No problems |

# Confounding

Doctors did not have any evidence for children with smaller thymus to compare to.

This was an obervational study not an experiment.

age

| thymus size | Child | Adult |
|---|---|---|
| Large | problems | No evidence |
| Small | No evidence | No problems |

# But sometimes…

... observational studies may be all that we have

We can use them as a beginning point,
to help us in our study but not to draw conclusions

Today all new medical procedures rely on clinical trials
that are a randomized comparative experiment

# To avoid confounding

Randomize

Observational Study
No treatment gets assigned to
the subjects by the experimenter

Randomized Experiment
Comparing results of treatments
assigned to subjects at random

Clinical Trial
Randomized experiment comparing
medical treatments.

For observational studies conditions are called factors and not treatments

# Factors and levels

The term factor is also used for experiments when there are many characteristics that want to be compared.

The different values that a factor may take are called levels.

Example: If Kelly added the type of diet to her experiment.

Factor 1
Type of Diet

| Factor 2<br>Length of Day | Light | Heavy |
|---|---|---|
| Short | Light-Short | Heavy-Short |
| Long | Light-Long | Heavy-Long |

# Randomization makes inference possible

(inference = to come to a conclusion)

By assigning treatments to units at random, there are only two possible causes for a difference in the responses to the treatments:

Chance or Treatments

If the probability is small that chance alone will give a large difference in the responses, then we can infer that the cause of the difference was the treatment.

# Control or comparison group

You need to compare your data to a control group.
Anecdotal evidence is not proof. Why?

Randy Pausch, professor at Carnegie Mellon University
While dying of cancer about various remedies for his illness

*I have received 10,000 emails, many of them telling me about different remedies.*
*But my first filter is: has it been through any kind of clinical study?*
***The plural of anecdote is not data.***
*So if you know people that did some alternative cure, that's positive, but it's not the same as real, clinically proven data.*

NY Times 2008

# Control or comparison group

Placebo Effect: When people believe they are getting special treatment they tend to improve.

Control Group: A group of people given a placebo.

Comparison Group: A group of people given the standard treatment (when comparing to a new treatment).

Blind Experiment: People do not know which treatment they are given.

Double Blind Experiment: patients and doctors do not know which treatment they are assigned

# Typical medical studies

Comparing treatment and placebo

Comparing new treatment and a standard one

Comparing a new treatment, an old one and a placebo

We always need
Random assignment of treatments
And a control or comparison group

An experiment that meets these criteria is called
Randomized Comparative Experiment.

# Hk

Page 208 E30, E31, E32, E33

Do old homework if you need to.

# E33

a. Factors: feeding method, education program, and hospital stay, each have 2 levels; 8 treatments total

b. List the mothers who volunteer
draw mothers and treatments at random;

c. No; we cannot assign birth weight to subjects.