Experiments and observational studies

- In an experiment, the investigator studies the effect of varying some factor that he/she controls.
- In an observational study, the investigator merely observes and records information on the subjects but does not manipulate any factors.
- It is very difficult to establish causation between one variable and another.
  - especially difficult based on observational studies

Koch’s postulates

- In 1890 the German microbiologist Robert Koch attempted to develop criteria for establishing whether a particular microorganism causes a particular disease
- not considered completely satisfactory today
- “... first, the organism is always found with the disease, in accord with the lesions and clinical stage observed; second, the organism is not found with any other disease; third, the organism, isolated from one who has the disease and cultured through several generations, reproduces the disease in a susceptible experimental animal. Even where an infectious disease cannot be transmitted to animals, the ‘regular’ and ‘exclusive’ presence of the organism proves a causal relationship.”

More formal criteria for judging whether an observed association is causal

- strength of the association
- dose-response relationship
- consistency of the association
  - Is the association observed in one study observed in other study populations, in studies using different methods, etc.
- temporally correct association
- specificity of the association
  - the alleged effect is rarely if ever observed without the alleged cause
- plausibility
Example: Female literacy and infant mortality

<table>
<thead>
<tr>
<th>Obs</th>
<th>infmort</th>
<th>femlit</th>
<th>country</th>
</tr>
</thead>
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<td>75</td>
<td>66</td>
<td>Bolivia</td>
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<td>83</td>
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<td>90</td>
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<td>Peru</td>
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<td>97</td>
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<td>50</td>
<td>TrinToba</td>
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<td>16</td>
<td>97</td>
<td>Uruguay</td>
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<tr>
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<td>16</td>
<td>98</td>
<td>Venezuela</td>
</tr>
<tr>
<td>24</td>
<td>21</td>
<td>90</td>
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</table>

The CORR Procedure

2 Variables: infmort femlit

Simple Statistics

<table>
<thead>
<tr>
<th>Variable</th>
<th>N</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Sum</th>
<th>Minimum</th>
<th>Maximum</th>
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</thead>
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<td>22.75181</td>
<td>806.000</td>
<td>7.00000</td>
<td>91.00000</td>
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<tr>
<td>femlit</td>
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<td>81.75000</td>
<td>17.41626</td>
<td>1962</td>
<td>36.00000</td>
<td>98.00000</td>
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</tbody>
</table>

Pearson Correlation Coefficients, N = 24

<table>
<thead>
<tr>
<th></th>
<th>infmort</th>
<th>femlit</th>
</tr>
</thead>
<tbody>
<tr>
<td>infmort</td>
<td>1.00000</td>
<td>-0.81421</td>
</tr>
<tr>
<td>femlit</td>
<td>-0.81421</td>
<td>1.00000</td>
</tr>
</tbody>
</table>

Prob > |r| under HO: Rho=0

infmort | femlit
--------|--------
<.0001  | <.0001 |

NOTE: 5 obs hidden.

Association does not by itself imply causation.
Confounding

Two variables (explanatory or lurking) are confounded when their effects on a response variable cannot be separated.

Populations and samples

• A population is the entire set of items about which we might wish to draw conclusions.
  – Example: I wish to find out the average income of families of current UI undergrads.
  – Example: A political pollster would like to know the Presidential preference of every registered voter in South Carolina.
  – Some populations we would like to study are hypothetical.
    * Example: all pregnant women who are infected with the HIV virus now and in the future
• A sample is the subset of the population that we can actually study (on which we can measure values of variables).

Bias

• The results of a study are biased if they are subject to systematic error.
  – i.e., there is something about the way the study is carried out such that, if we did many studies in this way, on average we’d get the wrong conclusions!
• One source of bias is if the sample is not representative of the entire population.
• The design of a study is biased if it systematically favors certain outcomes.
Kinds of sample designs

- simple random sample (SRS)
  - a sample of size $n$ individuals chosen in such a way that every set of $n$ individuals in the population has an equal chance to be the sample
  - the ideal
  - biased or unbiased?

- voluntary response sample
  - consists of people who choose themselves by responding to a general appeal
  - biased or unbiased?

- convenience sample
  - consists of subjects who are easy to get
  - biased or unbiased?

- judgment sample
  - consists of subjects chosen by an expert to be representative of the population
  - biased or unbiased?

How simple random samples are drawn

- each member of the population is uniquely identified in some way
  - example: the population of interest is UI students; each has a unique ID number

- intuitive idea: the identifiers are put in a hat and drawn at random

- usually actually done by a computer

- can be done manually using a table of random digits
  - first assign a unique numeric label to each member of the population
  - use table of digits to select labels at random.

Example

- I wish to get an idea as to how well undergrad students in 22S:30 like the textbook. To do this, I want to administer a lengthy interview and I have time to do only 3. Therefore, I want to draw a simple random sample of size 3 from the population of 24 undergrad students in the class.
• Begin by giving each student a unique numeric identifier.
  1. Derek A
  2. Kara
  3. Courtney
  4. Karen
  5. Cory
  6. Catherine
  7. Katie H
  8. Ryan
  9. Jenna
  10. Peter
  11. Anne
  12. Todd
  13. Anthony
  14. Katie McE
  15. Kimbra
  16. Phil
  17. Derek N
  18. Tuyet
  19. Ben
  20. Mitchell
  21. Nicole
  22. Cristina
  23. Joanna
  24. Jessica

• Use Table B in your book to find the first 3 of these identifiers that appear.

Table of random digits
- Each entry in the table is equally likely to be any of the 10 digits from 0 to 9 inclusive.
- The entries are “independent” of each other; i.e., knowledge of what digits are in one part of the table gives no information about the digits in any other part.

Using SAS to draw a simple random sample
  options linesize = 79 ;
  data students ;
  input name $9. ;
  datalines ;
  Derek A
  Kara
  Courtney
  Karen
  Cory
  Catherine
  Katie H
  Ryan
  Jenna
  Peter
  Anne
  Todd
  Anthony
  Katie McE
  Kimbra
  Phil
  Derek N
Tuyet
Ben
Mitchell
Nicole
Cristina
Joanna
Jessica
;
proc print data = students ;
run ;

Output
Obs Name
1 Derek A
2 Kara
3 Courtney
4 Karen
5 Cory
6 Catherine
7 Katie H
8 Ryan
9 Jenna
10 Peter
11 Anne
12 Todd
13 Anthony
14 Katie McE
15 Kimbra
16 Phil
17 Derek N
18 Tuyet
19 Ben
20 Mitchell
21 Nicole
22 Cristina
23 Joanna
24 Jessica

Proc plan
proc plan seed = 72950 ;
factors a = 3 of 24 ;
run ;
The PLAN Procedure
Factor Select Levels Order
a 3 24 Random
----a---
1 24 7
Using the same seed will reproduce exactly the same “random” choice!

```plaintext
proc plan seed = 72950;
factors a = 3 of 24;
run;
```

The PLAN Procedure

<table>
<thead>
<tr>
<th>Factor</th>
<th>Select</th>
<th>Levels</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>3</td>
<td>24</td>
<td>Random</td>
</tr>
</tbody>
</table>

----a----

1 24 7

Using a different seed will produce a different set of choices.

```plaintext
proc plan seed = 32542;
factors a = 3 of 24;
run;
```

Procedure PLAN

<table>
<thead>
<tr>
<th>Factor</th>
<th>Select</th>
<th>Levels</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>3</td>
<td>24</td>
<td>Random</td>
</tr>
</tbody>
</table>

----a----

2 16 4

Drawing from a larger population

```plaintext
proc plan seed = 241;
factors a = 100 of 1000;
run;
```

Procedure PLAN

<table>
<thead>
<tr>
<th>Factor</th>
<th>Select</th>
<th>Levels</th>
<th>Order</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>100</td>
<td>1000</td>
<td>Random</td>
</tr>
</tbody>
</table>

Other statistical sampling designs

- Statistical sampling is based on chance.
- A probability sample gives each member of the population of interest a known chance of being selected.
- stratified random sampling
  - procedure
    * first divide the population into strata
    * groups of similar individuals
    * draw a simple random sample from each stratum
    * combine the SRSs to form the full sample
    * ensures that each stratum is represented in the overall sample
Example: survey of class opinions on the textbook
- I might divide the class into men and women and take a SRS within each gender

- Probability sampling methods other than SRSs require more complicated statistical analysis than do SRSs.
  - But meaningful results can be obtained because we know what population was actually sampled and exactly how it was done.
  - This contrasts with voluntary response samples, convenience samples, and judgment samples.

Other possible sources of bias in surveys
- Undercoverage
  - The list of individual items from which a sample is chosen is called the sampling frame
  - Some segments of the population of interest are likely to be missed even with careful sampling methods because they are not included in the sampling frame
    - Example: telephone surveys systematically miss the 6% of American households without phones.

- Nonresponse
  - Some members of the chosen sample cannot be contacted or refuse to answer.
  - This biases the results of the survey if the members who do not respond are different from the general population.
  - Example: in surveys that include questions about household income, families with unusually low or unusually high incomes are less likely to answer that question than are families with moderate income.

- Response bias
  - Respondents may lie, especially about sensitive subjects.
  - Attributes or behavior of interviewers can make this more likely.
Example: In a survey concerning roles of family members, a father might tend to respond differently to the question “How many hours per week do you spend caring for your children on average?” depending on the gender of the interviewer.

- Bias due to wording of questions
  - leading questions
  - confusing questions
  - questions involving undefined terms
  - Example: Do you eat 5 servings of fruits and vegetables per day?