

## Attrition

- Attrition occurs in experiments when outcomes for all subjects cannot be measured.
  - The  $y$  value may be missing for some subjects.
- Example: Imagine studying a medicine that lowers blood pressure and therefore saves lives.
  - Experiment outcome table shows people in both treatment groups (indicated by 1) and control groups (indicated by 0).
  - Comparing the mean of both groups may lead to an incorrect conclusion that this drug raises blood pressure.

## Attrition (contd)

- Apples-to-apples comparison is lost due to attrition.
- Must consider the basis of the  $x$  values that may be used as comparisons.
- Apples-to-apples comparison may be lost when subjects are lost from only the control group.
  - Blood pressure comparisons between treatment and control groups cannot be made due to deaths in the control group.
  - Poor-quality trial for assessing the effects of this drug on blood pressure.

## Attrition by Movement: Easy Example

- Example: individual city tax returns as outcome data.
- Experiment conducted in several cities in a state to determine the outcome of raising the tax rate.
  - Concern is that if taxes go up, people may have a reduced incentive to work.
    - This could lead to a larger problem for society if people stop working.
  - Due to higher taxes in some cities, people may move away.
  - Many cities in the state, but experiment done on only a portion of them.
  - People move out of the treatment cities where taxes are raised and cannot be observed.
  - No longer an apples-to-apples comparison.
  - Cannot only look at the people who stayed.
    - It is unknown who in the treatment or the control groups would have stayed and been observable.
- Apples-to-apples comparison can be done only by knowing who is or is not observable.

## Attrition by Movement: Harder Example

- Example: city-level data of total hours worked in one year for all jobs.
- Some cities implement a policy to raise taxes.
- Do higher taxes lead people to work less?
- May not see attrition in the data received.
  - City may give only total numbers of hours worked for all jobs.
- Differences in total hours worked in a treatment city may be driven by people moving away.
  - Decrease in total hours worked may not be caused by people working fewer hours.

### **Attrition by Movement: Harder Example (contd)**

- May not know if people are missing when the numbers are only aggregate hours worked, not individual hours.
- Tests for differential attrition may not illustrate that attrition is occurring.
- Consider your conclusions when people opt out of being measured in an experiment.
- This experiment will answer what determines how many hours are worked in a city in a given year.
- This experiment will not answer what someone's individual behavior is because of differential attrition.

### **Attrition by Survey Nonresponse**

- Most common case of attrition.
- An example that actually occurred.
- Obama campaign asked, What is the effect of making phone calls to convince people to re-elect Barack Obama?

Obama Campaign Calls to Republicans

| Democrat | Monday<br>Obama<br>Call | Answers<br>Tuesday<br>Survey | Obama<br>Vote |
|----------|-------------------------|------------------------------|---------------|
| 0        | 0                       | 1                            | 0             |
| 0        | 0                       | 1                            | 0             |
| 0        | 1                       | 0                            | 0             |
| 0        | 1                       | 0                            | 0             |

Calls to Republicans and Democrats

| Democrat | Monday<br>Obama<br>Call | Answers<br>Tuesday<br>Survey | Obama<br>Vote |
|----------|-------------------------|------------------------------|---------------|
| 0        | 0                       | 1                            | 0             |
| 0        | 0                       | 1                            | 0             |
| 0        | 1                       | 0                            | 0             |
| 0        | 1                       | 0                            | 0             |

| Democrat | Monday<br>Obama<br>Call | Answers<br>Tuesday<br>Survey | Obama<br>Vote |
|----------|-------------------------|------------------------------|---------------|
| 1        | 0                       | 0                            | 1             |
| 1        | 0                       | 0                            | 1             |
| 1        | 1                       | 1                            | 1             |
| 1        | 1                       | 1                            | 1             |

## Attrition by Survey Nonresponse (contd)

- No treatment effect by making the calls.
- In the treatment group, only Democrats chose to answer the survey.
- Obama support in treatment group: 100%.
- In the control group, only Republicans chose to answer the survey.
- Obama support in control group: 0%.
- Calls appear to be extremely effective based on the results.
  - Everyone in the treatment group who answered the survey said they would vote for Barack Obama.
  - Everyone in the control group who answered the survey said they would vote for Mitt Romney.
- Attrition caused misleading results: appears that just calling people will convince all of them to vote for Barack Obama.
- Calls (treatment) did not change minds; it changed only who responded to the survey.

## Average Attrition

- "Average treatment effect" on ability to measure the outcome.
  - Possible test: Code a 1 or 0 outcome variable to determine if the outcome was observable.
- Is the measurement rate of the outcome the same in treatment and control?
  - Possible test: simple regression of response to survey on treatment assignment.
  - On average, determine if people are more or less likely to be observable in treatment or control.
    - This test may detect some types of differential attrition.
- No average differential attrition can conceal big differential attrition.

## Results From Obama Campaign Calls

|             | Control | Treatment |
|-------------|---------|-----------|
| Democrats   | 0%      | 100%      |
| Republicans | 100%    | 0%        |
| Average     | 50%     | 50%       |

## Balance on Ex Ante Covariates Across Treatment Groups

- Is there some indication that different groups were more or less likely to be observable differentially in treatment or control?
- Check for balance on ex ante covariates across treatment groups.
- Example: Obama campaign has 100,000 phone numbers they intend to call.
  - There is an equal distribution of Republicans and Democrats among the people they are calling.
  - Campaign conducts treatment and surveys.
  - Is there, on average, a similar likelihood of being a Democrat among those who answered the survey in both treatment and control?
    - No; there are more Democrats in the treatment group than in the control group.
  - May wrongly estimate the effect of treatment on the outcome because there is no longer an apples-to-apples comparison.

## Balance on Ex Ante Covariates Across Treatment Groups (contd)

- In a political example, look for differences in income or political party.
- If treatment causes Republicans to attrit (to leave the sample), party affiliation will no longer be balanced in the final sample.
- $P \supset Q \rightarrow \sim Q \supset \sim P$  but not  $\sim P \supset \sim Q$ .

## Differential Attrition Concealed

- Although something could be diagnostic of differential attrition, differential attrition still may exist.
  - You see there is no average differential attrition, and your observable covariates are still balanced.
- There could still be attrition in something you can't measure.
- There may be differential attrition due to treatment.
  - Especially applies in political and commercial examples when people are voluntarily agreeing to be measured but some treatment may change their behavior.
  - We may not be able to observe why people chose to take or not take our survey.
- Random attrition between control and treatment groups is acceptable because there is an apples-to-apples comparison.

## Differential Attrition Concealed (contd)

- However, we don't know if it is actually random attrition.
  - In the Obama survey case, it was not random.
  - There was differential attrition by party.
- Consider: Is the average attrition different across groups?
  - Even though there is 50% attrition in both treatment and control, you still have a completely different composition of Republicans and Democrats in the groups.
- Initial conclusion was treatment was very effective: Calls convinced people to vote for Obama.
- Looking at the covariate balance revealed this was a false conclusion.
- Differential attrition can be totally undetectable, even when it biases your conclusions.



## Avoiding Attrition With Surveys

- Conceal the purpose of the survey.
  - Convince people to take the survey without participants knowing it is related to a treatment they have already received.
- Increase response rate overall.
  - Likelier to get a more representative sample when response rate is higher.
  - Example: YouTube ads were replaced with surveys so that people must take the survey to watch the video.
    - Also eliminates differential attrition.
    - If forced to take the survey, less likely that they are taking it due to the treatment.
- Secure commitments from subjects.

## Other Methods to Avoid Attrition

- Locate a subject pool unlikely to attrit.
  - Example: in the income tax study, may decide the subjects will be people with children since they are less likely to move
- Consider other measurement strategies.
  - Example: You plan to do a study on a website using a survey.
    - You will call everyone who saw the ad and ask if they purchased the product.
  - Instead, you could measure conversions on a website.
    - In order to attrit, someone would have to clear the cookies on his or her computer.
    - After seeing the ad, people are less likely to attrit by clearing their cookies than if they were asked to answer a survey.
  - Clearing the cookies is less likely to be differential attrition.

## Mediation

- The study of why a treatment has a certain effect.
- Treatment may not have a direct effect on Y.
- The mediator is an intervening variable the treatment changes that causes Y to change.
  - $T \rightarrow M \rightarrow Y$
- Example 1: Chewing bark → lessens pain.
  - Why?
    - Aspirin in the bark (mediator)
  - Why does aspirin work?
    - Biological mechanism that reduces pain (mediator)
  - Why?

## Mediation (contd)

- Example 2: Fruit juice → cures scurvy.
  - Fruit juice (treatment) cured scurvy (outcome) through vitamin C (mediator).
  - Why?
- Never-ending chain of "whys."
- Common criticism of experiments: statistics doesn't tell us why something has an effect.
- Always more questions to ask.

## Typical Approach to Mediation Analysis

- **Do not use this approach** because the analysis is typically biased.
- Example: Lime juice cures scurvy by increasing vitamin C levels.
- Mediator =  $\alpha + \beta_1 \times \text{treatment}$ 
  - Does lime juice lead to higher levels of vitamin C?
- Outcome =  $\alpha + \beta_1 \times \text{treatment}$ 
  - Is there an average treatment effect on the outcome?
  - Does lime juice lead to less scurvy?
- Outcome =  $\alpha + \beta_1 \times \text{treatment} + \beta_2 \times \text{mediator}$ 
  - What is the effect of lime juice (treatment) on scurvy (outcome) once we control for vitamin C levels (mediator)?

## Typical Approach to Mediation Analysis (contd)

- Result: The treatment is no longer effective when we control for the mediator.
- However, doesn't definitively establish that the mediator caused the treatment to lose effect.
- The mediator was not randomly assigned.
- The treatment may have affected other mediators.
- Other potential mediators correlated with the mediator that was measured.
- May see the same outcome with different mediators.
- This type of mediation analysis cannot determine if a particular mediator is responsible for why a treatment has an effect.

## Why Mediation Is Difficult to Study

- Mediation analyses are always suggestive, never definitive.
- Experimental estimates of indirect effects must affect **only** the mediator in question.
  - What is it in fruit juice that cures scurvy?
  - Randomly assign vitamin C pills.
- In the social sciences, treatment may have several potential causal pathways.

## Why Mediation Is Difficult to Study (contd)

- Mediators often unmeasurable.
  - Cannot be sure which mediators are being changed with the treatment
  - Cannot be sure that all possible mediators have been measured
- Causal heterogeneity:
  - Subjects are differentially affected by changes in X and M.

## Program of Research

- Mediation usually isn't critical but suggests more research.
  - Example: Fruit juice cures scurvy.
  - The reason fruit juice cures scurvy may not matter.
  - However, mediation analysis leads to the hypothesis that vitamin C cures scurvy.
  - Future research may find that vitamin-C pills can be used on ships rather than a crate of limes.
- Mediation analyses can guide thinking and suggest hypotheses.
- But will not be certain a particular mediator is the cause of why a treatment had an effect.

## Implicit Mediation Analysis

- Theory testing by looking for subgroup effects
- Example in political study:
  - Theory: People are more likely to adopt the views of politicians of their own parties.
  - Treatment group: receives letter from a Democratic politician stating his position on an issue.
  - Control group: does not receive letter.
  - Theory leads you to believe that Democrats will accept the position in the letter more than Republicans.
  - Theory is tested but it is not dispositive; may be other reasons Democrats adopted the position in the letter.
- Cannot be certain why a treatment had an effect
- Tests theories to see how consistent they are

## Bolger and Amarel Study

- Social psychologists hypothesized: Social support reduces stress due to an increase in self-confidence.
  - Common and ineffective way of studying this: Measure self-confidence after someone has received social support.
    - Find that the effect of social support goes away when we control for posttreatment self-confidence.
- Bolger and Amarel randomly assign the mediator:
  - Conducted an implicit mediation analysis with an experiment
  - Randomly assigned a confederate (research assistant who posed as a peer) to either speak in a self-confidence-enhancing way or not after giving subjects a stressful task

## Bolger and Amarel Study (contd)

- Result: The confidence-enhancing support worked; non-confidence-enhancing support did not.
- What we learn: The words used in the confidence-enhancing support worked; the non-confidence-enhancing support did not.
- What we don't necessarily learn: Confidence itself is responsible for reduced stress.
  - For example, maybe the words used to enhance confidence also affected happiness, which reduced stress.
- Takeaway: In other settings, such as hospital patients, it may be a good strategy to use words from the confidence-enhancing support to reduce stress.
- Mediation analysis can be useful for suggesting other treatments but can never be dispositive about what causes a treatment to work in the real world.

## Generalizability

- The limitations of any one experiment to apply to other subjects in other contexts

## Generalizability of Subjects

- In an experiment, results apply to the estimated causal effects only among the given sample.
- Example: new cancer drug that has not been tried in humans.
  - People volunteer for this medical trial and are assigned to either treatment or control.
    - Volunteers are already in various serious conditions.
  - Results show a large positive treatment effect among dire medical cases.
    - Results may not apply to patients with a more mild stage of cancer.
  - Medical trials need a wide variety of populations in different stages of the disease.

## Generalizability of Subjects (contd)

- Consider how volunteers may differ from the broader population when patients self-select into an experiment.
  - Results for dire patients may not generalize to patients with milder cancer.

## Generalizability of Treatments

- Treatments first tested in research hospitals, with highly trained and educated staff, tend to be more effective than when tested in other hospitals.
  - Research hospital doctors may be better at following the protocol and managing patients with side effects.
  - Therefore, treatment is different in research hospitals compared to others.



## Generalizability of Treatments (contd)

- Generalizability of research partners who agree to administer a treatment
- Example: job training program partner
  - Study to evaluate the effect of a job training program.
    - Send letters to job training programs asking them to randomly choose 500 people to be evaluated.
    - 20 programs agree to participate.
  - Results show all programs highly effective in placing people in jobs.
  - However, selection of programs was not random; 1000 sites were asked to participate, but only 20 agreed to be evaluated.
  - Maybe only those programs who knew they were effective agreed to participate.

## Opower Program

- Allcott (2014) paper.
- Program sent people letters that compared their electric usage with that of their neighbors.
- People who were using more electricity than their neighbors reduced energy consumption over the next few months.
- Environmentally conscious areas were the first to sign up for the initial pilot program.
  - The program in these areas showed large effects.

## Opower Program (contd)

- Subsequent cities signed up and showed smaller effects.
- People and partners most willing to try a new intervention may be most likely to benefit.
  - Reverse can be true too; those least willing to give up something may benefit the most.
- Consider how results might change when you try an experiment with another population.

## Lucking-Reiley Auction Study (1999)

- Reported results showing that Dutch auctions (price continues to lower until a bidder accepts the price) raised more revenue than first-price sealed-bid auctions (bids simultaneously submitted with a deadline; highest bid wins)
  - Does the same result hold for goods other than *Magic: The Gathering* cards?
  - Does the result hold for in-person bidding, or bidding on websites, instead of just bids submitted via e-mail?
  - Does the result hold when the Dutch auction is fast rather than slow?
    - Reiley's auctions had one price change per day; flower auctions in Holland change price in fractions of a second.

## Lewis and Reiley Online Advertising Study (2014)

- Reported that online advertising increased in-store purchases.
  - Do the results hold for other retailers?
  - Do the results hold when the subjects are not existing customers of the retailer?
  - Do the results hold for advertising done on sites other than *Yahoo!*?
  - Do the results hold for offline advertising?
  - Were the results specific to the actual ad creatives used?
  - Do the results hold in time periods other than fall 2007?
- In general, we don't know if the results generalize until we replicate.

## Get Out the Vote Campaigns

- Professors tried a strategy in an off-year Michigan primary election where few people typically vote or know about the election.
  - Results showed Get Out the Vote strategy is very effective.
  - When the treatment was tried in a presidential election, the effects were much smaller.
- How treatment effects differ across people and across context may not be obvious until we conduct further experiments.
- After many experiments, Get Out the Vote can now make empirical generalizations.
  - Hundreds of experiments allowed them to find regularities so we can accurately forecast causal effects.
- No experiment applies to all circumstances.

## Attrition

- Treatment has an effect on which units are observed, ruining comparability.
- Strategies for detecting attrition:
  - Is there an average effect on attrition on whether people's outcomes are measurable?
  - Are covariates still balanced among those for whom the outcomes are measurable?
- Try to reduce attrition in design.
  - Design a measurement procedure that is less sensitive to attrition.

## Mediation

- The study of why a treatment has an effect.
- Fundamentally unanswerable question.
  - Cannot know for sure why a treatment worked
- "Implicit mediation" analysis can guide hypothesis generation.

## Generalizability

- Your results pertain only to the sample and context of that particular study.
- Cannot ever know for sure how your experiment will differ in other contexts.
- Perform other experiments to validate that your results would replicate in other circumstances.