36-303: Sampling, Surveys and Society

Sample Size, Sampling Frame, Questions

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Handouts & Other Things…

- Handouts…
  - These Lecture Notes
- Other Things…
  - Next week we have a midterm test!
    - I will talk a little about the midterm on Thursday, and more next Tuesday.
  - See last week's lectures for upcoming due dates
    - HW04 today; TWA Thu, Project Assignmen I.4 next Thursday…
- Later today or tomorrow I will EMAIL
  - Update on Team Project Assignments

Outline

- Team Project Progress
- Sample sizes for SRS's
- Population, Sampling Frame, Random Sample ***[Important for Team Assig. I.4!]***
- Some Non-response Strategies
- Questions and Answers in Surveys ***[Important for Team Assig. I.5!]***

Team Project Progress

- All teams have chosen projects
  - I will email feedback on I.3 shortly.
- The topics for this semester are:
  - A political survey of the CMU community
  - Music/movie internet piracy at CMU
  - How to improve our on-campus parking system?
  - Political Attitudes and Academic Major at CMU
  - Analysis of the Off-Campus Housing Search for CMU Students
  - Parking Meters at CMU
  - Spatial and Analytic Study of Student Housing at CMU

Survey Sample Size Estimation

- *Review*: CLT-based conf. interval and sample size calculation for ***SRS with replacement:***
  - 100%(1-α) CI for μ:

$$\left(\overline{X} - z_{\alpha/2} \frac{SD}{\sqrt{n}} \ , \ \ \overline{X} + z_{\alpha/2} \frac{SD}{\sqrt{n}} \right)$$

  - Margin of error (ME) is ½ width of CI, so

$$ME \ = \ z_{\alpha/2} \frac{SD}{\sqrt{n}}$$

  - For a given ME, get sample size by solving for n:

$$n \geq n_0 \ , \quad \text{where } n_0 = \frac{z_{\alpha/2}^2 (SD)^2}{(ME)^2}$$

Survey Sample Size Estimation

- *New*: CLT-based conf. interval and sample size calculation for ***SRS w/o replacement:***
  - 100%(1-α) CI for μ requires FPC:

$$\left(\overline{X} - z_{\alpha/2}\sqrt{1-\frac{n}{N}}\frac{SD}{\sqrt{n}}\ ,\ \ \overline{X} + z_{\alpha/2}\sqrt{1-\frac{n}{N}}\frac{SD}{\sqrt{n}}\right)$$

  - For a given ME, get sample size by solving

$$z_{\alpha/2}\sqrt{1-\frac{n}{N}}\frac{SD}{\sqrt{n}} \ < \ ME$$

  - After some algebra, get

$$n \geq \frac{Nn_0}{N+n_0}\ , \quad \text{where } n_0 = \frac{z_{\alpha/2}^2 (SD)^2}{(ME)^2}$$

Example: Sample Size Estimation

- *Estimate proportion of CMU undergrads who would prefer one week for carnival, to within +/-0.05, with 95% confidence.* *How large n?*
- For SRS with replacement

$$n \geq n_0 \ , \quad \text{where } n_0 = \frac{z_{\alpha/2}^2 (SD)^2}{(ME)^2}$$

  - ME = 0.05; z = 1.96 (or 2); SD = $\sqrt{p(1-p)}$, but p is what we want to estimate!
    - Initial guess for p? Maybe p=0.9?
    - Worst-case guess for p? p=0.5.

Example: Sample Size Estimation (2)

- Go with ME = 0.05, z = 1.96, and
  SD = $(0.5*(1-0.5))^{1/2} = 0.5$

- For ***SRS with replacement***, we get

$$n_0 = \frac{z^2_{\alpha/2}(SD)^2}{(ME)^2} = \frac{(1.96)^2(0.5)^2}{(0.05)^2} = 384.16$$

  so, sample n $\geq$ 385 students.

Example: Sample Size Estimation (3)

- For SRS with replacement, we take n at least

$$n_0 = \frac{z^2_{\alpha/2}(SD)^2}{(ME)^2} = \frac{(1.96)^2(0.5)^2}{(0.05)^2} = 384.16$$

- For ***SRS w/o replacement*** (www.cmu.edu Factbook claims 6020 undergraduates at CMU), we take

$$n \geq \frac{N \cdot n_0}{N + n_0} = \frac{(6020)(384.16)}{6020 + 384.16} = 361.11$$

a savings of about 23 students.

Population, Sampling Frame, Random Sample

- ***Target Population***: The population about which you can make valid inferences from a well-designed survey within your means.
- ***Sampling Frame***: A real or theoretical list of all possible individuals in the *target population*, that you could randomly sample in your survey.
  - Hopefully, differs *only in small ways* from target pop.
- ***Random Sample***: A random, probability based sample (for us, usually SRS without replacement) from the sampling frame.

  The only *guarantee* of a representative sample, that we trust statistical calculations with, is a truly *random*, probability-based sample from a *sampling frame* with *low coverage error* for the *target population*.

Population and Sampling Frame

- If your population is “all undergraduates at Carnegie Mellon”, then your sampling frame should be one of these (most likely):
  - List of email addresses obtained from Hub or elsewhere; or
  - C-Book student directory
- If your population is “all residents of XYZ part of Pittsburgh” then your sampling frame should be (most likely):
  - A list of addresses that you can visit or send mail to; or
  - A list of phone numbers you can access via random digit dialing

A Good Sampling Frame Simplifies Representative Sampling

- It should be a real or theoretical list that has low coverage error
  - It should contain almost exactly the same individuals as the full target population

- It should be possible to select a real, live random sample from the frame
  - A frame like “all students passing the Fence between 12:00 and 1:00” has obvious problems (*coverage error* and *statistical calculations may not apply*).

Goals for the Random Sample

- For most of the projects, the Random Sample should be an ***SRS without replacement*** (urn model!) from an explicit sampling frame.
- Some projects may have natural *strata* (major department of student, fr/so/jr/sr, or 3-4 different college campuses). In that case take an ***SRS w/o repl.*** from each *stratum*.
- In some extreme cases it is not possible to build a frame and do random sampling (e.g. survey of panhandlers, survey of riders while they are on 28X).

Non-Response Strategies

- Once you have chosen the random sample, respondents can screw up representativeness by forgetting or refusing to respond to your survey.
- For mail and email surveys, common strategies are
  - Pre-survey announcements
  - Followup reminders
  - Other methods?
- For face to face and telephone surveys, *practice*:
  - How to pull respondent in, in first 10-30 seconds;
  - How to keep respondent engaged for whole interview
- How many times to re-contact a dead-end in sample?
- IRB: maintain right to refuse, quit early, etc.

Two Fractions: Sampling Fraction vs. Response Rate

- The *sampling fraction* f = n/N (n = sample size; N = population size)
  - Determines variability of sample;
  - FPC = $\sqrt{1-f}$ for SE's and similar quantities
- The *response rate* r/n (r = # who responded; n = number in sample).
  - If the sample is random and r/n $\approx$ 1, then the r respondents are probably representative of population
  - If ***either*** nonrandom sample, ***or*** r/n << 1, then the respondents are probably not representative of population
- r/n $\approx$ 1 is much more important than n/N $\approx$ 1.

Example: Student use/attitudes toward drug/alcohol use (Fictional!)

- *Target Population*: All currently enrolled undergrads at the Pittsburgh campus of CMU
- *Sampling Plan*: Advertise on Facebook inviting students to come to www.surveymonkey.com to fill out survey.
  - ***No sampling frame*** specified
  - ***Two sources of coverage errors***
    - Not everyone is on Facebook
    - Volunteers are different
  - ***Nonrandom sample*** – no way to claim representativeness unless n/N is *very* close to 1!
  - ***No plan*** to identify ***nonresponders*** or ***followup*** with reminders

Example: Student use/attitudes toward drug/alcohol use (Fictional!)

- ***Target Population***: All currently enrolled undergrads at the Pittsburgh campus of CMU
- ***Sampling Plan***: Take SRS w/o replacement from C-book, email those students to do Surveymonkey survey, email reminders to nonresponders after 1 week.
  - ***Sampling Frame*** C-Book is a list of individuals in target pop
  - ***Low Coverage Error***
    - Students who provide wrong or late information for C-Book
  - ***Random sample*** – makes sample representative of frame, and because of low coverage error, sample is also representative of target population
  - ***Followup Nonresponders*** with email reminder
    - ***Increase response rate***
    - ***Decrease appearance of confidentiality***

Example: Use/attitudes toward PAT bus service (Fictional!)

- ***Target Population***: East End Residents (Oakland, Shadyside, Squirrel Hill, Point Breeze)
- ***Sampling Plan***: Approach people at bus stop with questionnaire
  - ***No sampling frame*** specified
  - ***Two sources of coverage error***
    - Time/place → who is there (workers, single moms w/kids, …)
    - Noncoverage of non-riders or infrequent riders
  - ***Nonrandom sample*** → can't argue "representative"
  - No definition or followup plan for ***nonresponders***

Example: Use/attitudes toward PAT bus service (Fictional!)

- ***Target Population***: East End Residents (Oakland, Shadyside, Squirrel Hill, Point Breeze)
- ***Sampling Plan***: Identify all East End phone prefixes (361, 362, 682, …), randomly select prefix and 4-digit suffix (ppp-ssss); phone interview starts by verifying residence and then asks about buses.
  - ***Sampling Frame*** East-end telephone land lines
  - ***Lower Coverage Error***
    - Frame + location screen question → subset of target pop
    - Noncoverage of persons w/o landlines (Groves, sect 4.8!)
  - ***Random sample*** → Easy "representativeness" argument
  - ***Nonresponders not mentioned*** (but one could call back non-answering numbers [how many times?])

Accessible Sources of Sampling Frames: Face to Face or Mail-Back

- Residential addresses
  - Phone directories are easy, but may have under-coverage problems
  - *Clustered* sampling based on random selection of block within area, & random selection of house within block
- Commercial addresses
  - Free online services provide addresses of specific business types within x miles of a particular location – under-coverage problems?
  - For storefronts, the random block/random storefront scheme can work
- Man on the Street interviews
  - Coverage problems based on respondents' habits
  - Volunteer self-selection problems

Accessible Sources of Sampling Frames: Telephone Interviews

- Phone books
  - Easy but can have under-coverage problems
  - University directories can be better
- Random digit dialing
  - Easy to formulate – select a valid prefix at random, then select a random 4-digit suffix (ppp-ssss)
  - Under-coverage (land-lines only)
  - Ineligible numbers (residential vs. business vs. fax, disconnected): Groves 4.8 estimates 6-7 dead-end calls needed for every "good" call
- Advertising a number for respondents to dial in
  - Coverage problems based on where you advertise
  - Volunteer self-selection problems

Accessible Sources of Sampling Frames: Email/Web Survey (Initial Considerations)

- Can be appropriate for "connected" populations (not yet for "general public") – University students, online workers, online entertainment users, etc.
- Sampling frame must be a list of email and/or paper mail addresses
  - University directories (e.g. C-Book)
  - Other email lists from registrar's office etc.
- *Good*: Take random sample from frame, then invite through email and/or paper mail
- *Bad*: Passive advertisement (Facebook etc.)
  - Under-coverage
  - Volunteer self-selection
  - Facebook can be ok to contact people you have sampled from some other frame, but is not itself a good frame.

Accessible Sources of Sampling Frames: Email/Web (Implementation)

- Can embed survey in email and ask respondents to email responses back to you
- Or use an online service, e.g.:
  - www.surveymonkey.com
  - www.infopoll.com
  - www.surveysaid.com
  - questionpro.com
  - Google Docs has forms that will work
- Decrease non-response with email and/or paper mail reminders
  - In order to have non-response followup, you need to know who in your sample has already responded!
  - Think of ways to assure confidentiality ***anyway***.

Non-Framed, Non-Random Samples

- Non-Framed Samples
  - Challenge: *Coverage error*
    - *Why should anyone believe your sampling method provides good coverage of your target population?*
- Non-Random Samples
  - Challenge #1: *Selection bias*
    - *What makes people eligible for your survey?*
    - *How do you choose among the eligible units?*
  - Challenge #2: *Using standard statistical formulae*
    - *How can we be sure that the sample is large enough to provide good population estimates?*
    - *How can we be sure formulae for means, variances, confidence intervals, etc., do not need further modification?*

Non-Framed Samples

- Describe all of the locations, times, and methods of approaching respondents (or objects) in great detail.
  - *Coverage:* Is everyone in your target population accessible at these times and places?
  - *Equally-likely sampling:* Is everyone equally likely to be there when you are there?
  - *Eligibility:* How will you determine whether to include this respondent in your survey.
    - Target population undergrads, this guy has grey hair and a paunch (are there undergrads like that?)
    - Are there reliable ways to determine eligibility?

Non-Random Samples: Selection Bias

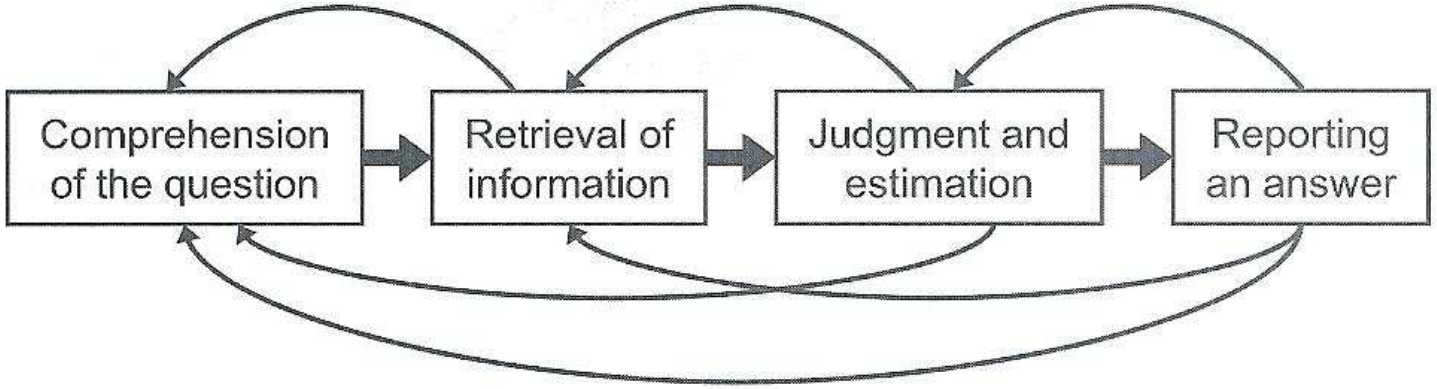
- Volunteer bias (E.g. Facebook or general email invitation to a non-targeted sample)
- Interviewer bias (E.g. you never approach unattractive respondents at the Fence).
- Possible Fixes:
  - Decide on a rule for targeting subjects in advance (select every fifth person who passes by the Fence) and stick with it, no matter what.
  - Decide how you will follow-up nonrespondents (just like with a targeted random sample!)

Non-Random Samples: Using Standard Statistical Formulae

- Show that your non-random sample "behaves" like a random sample
  - Means match gender, age, college class, income, etc. features of the target population
  - Variances match variances you would expect from a random sample
- As further protection against coverage error, take a larger sample
  - (Sue & Ritter, 2007, *Conducting On-line Surveys*, p. 34):
    - Useful sample sizes are typically 30-500
    - Within that range, sample roughly 10% of total population
    - Sample should be roughly 10 times larger than number of variables being studied
    - Choose the largest sample you can afford

Questions and Answers

- A simple model of the response process (Groves, Ch 7):



- Survey question should be written and refined to
  - Increase validity (reduce errors and misunderstanding)
  - Increase reliability (get the same answer every time)

  at every stage in the response process!

Comprehension of the Question

- ***Does respondent understand what you intend by the question?***
- Some possible problems:
  - Not possessing information needed for question
  - Misunderstanding question wording
    - Grammatical errors or style
    - Too much complexity
    - Question contains false or unproductive assumptions or inferences
    - Vague or unfamiliar concepts, quantifiers, terms

Retrieval of Information

- ***Can respondent recall information from long-term memory?***
- Some possible problems:
  - Mismatches between terms in question and terms in respondent's memory
  - Retrieval failures (I forget…)
  - Distortion or poor reconstruction of remembered events as time goes by
    - Time dilation
    - Rehearsal (or avoidance!) of significant memories

Judgment and Estimation

- ***How does respondent combine, edit, fill in, information needed to answer question?***
- Typical estimation methods for incomplete quantitative memories:
  - **Exact answer**: I just did my taxes, so I know my income is…
  - **Recall-and-count**: Recall events and count them up, add a few in case I forgot some
  - **Rate-based**: Recall the typical rate at which the events occur, and multiply by the time period
  - **Impression-based**: Start with a vague impression (few, some, a lot) and translate into a quantitative estimate
  - Over- & under-reporting – collect validation data!

Judgment and Estimation (continued)

- Typical judgment methods for attitudes:
  - **Deep impressions**: respondent has thought a lot and has deep evidence and reasoning to support attitude
  - **Shallow impressions**: "Gee I was just reading about PAT buses and they don't sound very reliable."
  - **Top-down judgement**: "I believe in the free market generally, so I think everyone should pay for their own bus pass."
  - **Bottom-up judgement**: "I remember being a poor student without access to transportation, so I think people with means should be taxed to make free bus passes available for students."
  - **Reaction to question wording**:
    - Do you think the United States made a mistake in deciding to defend Korea? [Gallup]
    - Do you think the United States was right or wrong in sending American troops to stop the Communist invasion of South Korea? [NORC]

Reporting the Answer

- ***What does respondent select to respond?***
- Question Format
  - Open-ended questions (numerical or verbal)
  - Closed questions with ordered scale (Likert scale)
    - Anchoring vignettes can help interpret responses in some cases!
  - Closed questions with categorical responses (M/C)
- Failure to Follow Instructions
  - Comprehension of instructions
- More or less deliberate misreporting & nonresponse
  - Sensitive questions
  - Desire to mislead polling organization
  - Undervalue poll or polling agent (*"it's <u>just</u> a student project…"*)

Review

- Team Project Progress
- Sample sizes for SRS's
- Population, Sampling Frame, Random Sample
- Some Non-response Strategies
- Questions and Answers in Surveys

- HW04 due today
- TWA due this Thursday
- I.4 Due next Thursday
- Midterm Exam Next Thurs