Complex Samples

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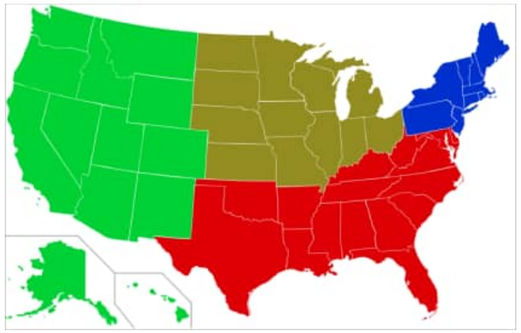
Lecture Overview

Complex Sample = any probability sample where design involves more than Simple Random Sampling (SRS)!

- More in-depth review of complex samples
- Discuss important considerations for making population inferences based on complex samples

Features of Complex Samples: Stratification

- **Stratification**: Allocation of overall sample to different "strata", or mutually exclusive divisions of the population (e.g., regions of the United States)

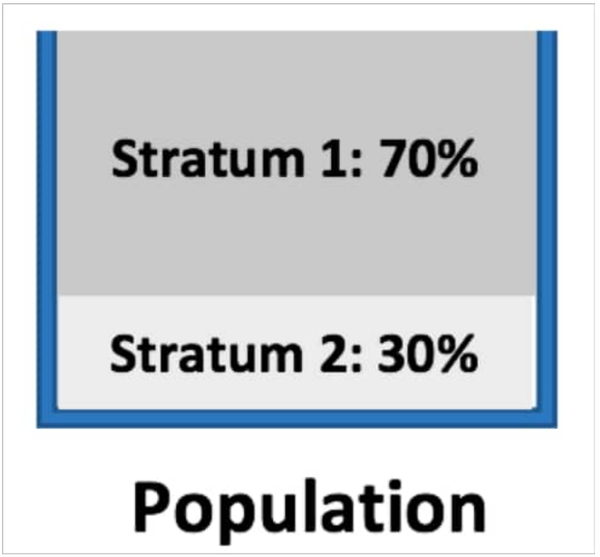


- Several different allocation schemes are possible; Aim → minimize sampling variance for particular variables given fixed costs

Features of Complex Samples: Stratification

Example: *Proportionate* Allocation

- If 70% of a population appears in one stratum and 30% in the other;
- Then 70% of the overall sample would be allocated to the first stratum, and 30% to the second



Features of Complex Samples: Stratification

- Stratification will eliminate between-stratum variance in means (or totals) on variable from the sampling variance!

- Important to account for stratification in analysis; else sampling variance may be artificially large → inferences too conservative, confidence intervals too wide!

Features of Complex Samples: Clustering

- **Clustering**: Random sampling of larger clusters of population elements, possibly across multiple stages (e.g., counties, then segments, then households)

- Reduces cost of data collection: expensive $$$ to visit *n* randomly sampled units from large and widespread population

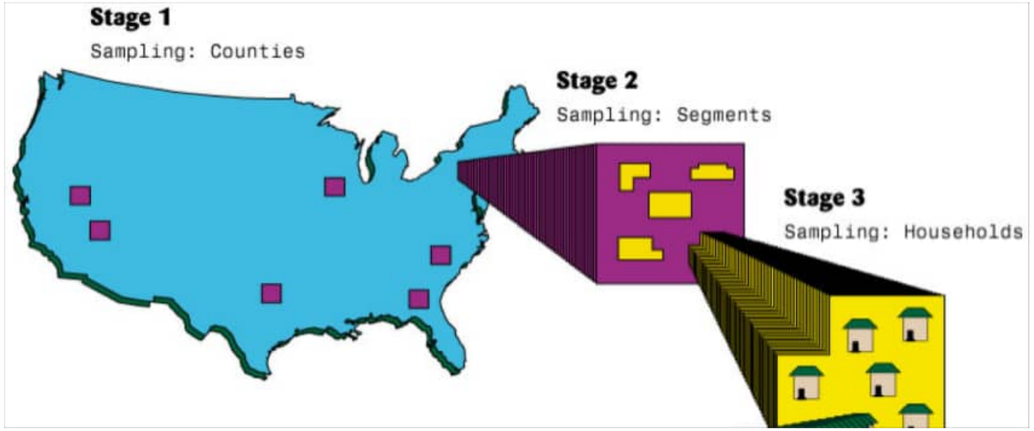


Image Credit: L. Mahadjer, Westat

Features of Complex Samples: Clustering

- Clustering *reduces* costs 😀
  BUT tends to *increase* sampling variance of estimates 😔
  Why? Units within same cluster have similar (correlated) Values on variables of interest → don't measure unique info!

- **Important** to account for cluster sampling in analysis, else inferences too *liberal*, confidence intervals too *narrow*!

Features of Complex Samples: Weighting

Complex samples are still probability samples, but if …

- Multiple stages of cluster sampling within strata
- Or certain subgroups sampled at higher rates (oversampling)

→ **Unequal probabilities of selection** for different units

Need to account for these unequal probabilities to make **unbiased** population inferences

Features of Complex Samples: Weighting

- **How**? Use of **weights** in analysis …
  (partly) defined by **inverse of probability of selection**

If my probability is 1/100 → my weight is 100,
I represent ***myself*** and **99 others** in the population!

Features of Complex Samples: Weighting

- Weights also **adjusted** for different probabilities of responding in different **subgroups**

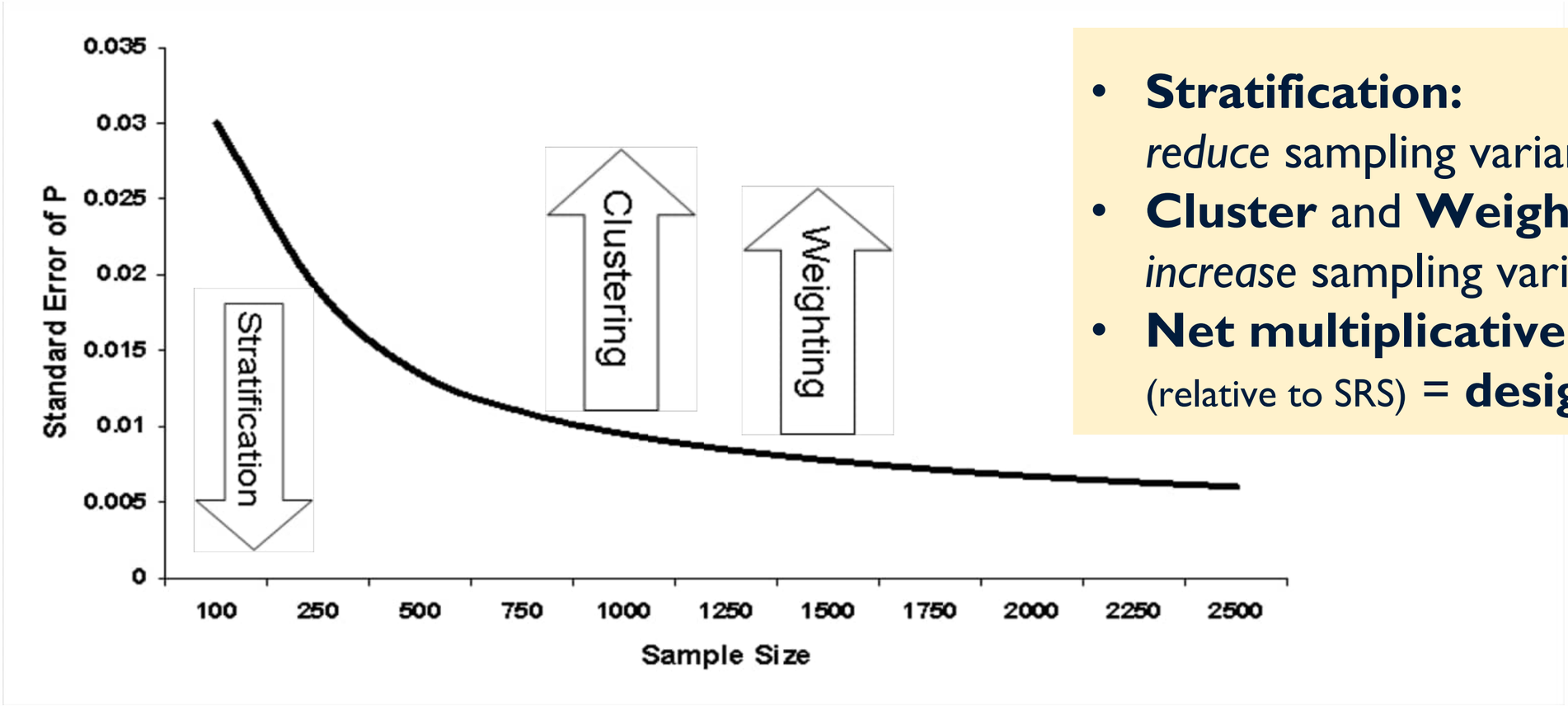
If my probability of selection = 1/100
and I belong to subgroup where only 50% responded
→ my adjusted weight = (1/0.01) x (1/0.5) = 200

Features of Complex Sampling: Weighting

- **Important** need to use weights so estimates are unbiased with respect to the sample design; else possible serious bias!

- **Drawback**: like cluster sampling, highly variable adjusted survey weights tend to increase sampling variance of weighted estimates *(even if they produce unbiased estimates!)*

Visualizing Design Effects



- **Stratification:** *reduce* sampling variance
- **Cluster** and **Weighting:** *increase* sampling variance
- **Net multiplicative change** (relative to SRS) = **design effect**

Source: *Applied Survey Data Analysis (Heeringa et al., 2017)*

Complex Samples in Analysis

- Most "survey analysis" procedures in statistical software compute unbiased point estimates (using final survey weights) and unbiased estimates of sampling variance (using stratum and cluster information, or *replicate sampling weights*)

- **Important** need to use appropriate software procedures, and identify all of these features to the software!

Analytic Error...

- Many secondary analysis of survey data collected from complex samples don't do this
  → can lead to biased inferences based on survey data

- Deeper Dive References:
  - http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0158120
  - https://www.cdc.gov/pcd/issues/2018/17_0426.htm

Important: Look at Documentation!

- Focus = **looking at data** and understanding where data come from
- *Survey data*: Look at the documentation **before** the data!
- Documentation = what complex sampling performed, and what variables capture complex sampling features (weights, stratum codes, cluster codes)

Keywords indicating need to account for complex sampling:
multistage sampling, weights, stratification, cluster sampling, design effects

What's Next?

- **Later courses**: Analyses of survey data from complex samples, and methods in Python for computing unbiased (weighted) estimates and unbiased estimates of sampling variance

- **Deeper Dive Reference**

  Applied Survey Data Analysis: http://isr.umich.edu/src/smp/asda/