Sampling

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Introduction to Sampling: Definitions

Reference: Sampling: Design and Analysis, by S. Lohr (1999).

- **Observational unit** An object on which a measurement is taken.
- **Target population** The complete collection of observations that we want to study.
- **Sample** A subset of the population
- **Sampled population** The population from which the sample was taken.
- **Sampling unit** The unit we actually sample.
  - E.G., we may want to study individuals, but do not have a list of individuals in the target population. Instead we sample households. The observational units are the individuals living in the households.
- **Sampling frame** The list of sampling units.

Selection Bias

- Selection bias occurs when some part of the target population is not in the sampled population.
  - For example, if a survey of household income omits transient people, the estimates of average household income are likely too large.
- Convenience samples are often biased, since the units that are easiest to select or are most likely to respond are usually not representative.
  - Mall surveys, mail-in surveys, web surveys.
  - Nonresponders often differ from responders.

Probability Sampling

- In a probability sample, each unit in the population has a known probability of selection.
- In a **simple random sample** (SRS), every unit in the population has the same probability of being included in the sample.
- In a **stratified random sample** the population is divided into subgroups, or strata, and an SRS is taken from each stratum.
- In a **cluster sample**, observation units are aggregated into larger sampling units called clusters. We draw a sample of clusters and then subsample all or some observational units within the sampled clusters.

Stratified Random Sampling

- One example is case-control sampling, where we draw separate samples from the population of cases and controls.
  - The motivation is our need for a representative sample of a rare segment (cases) of the population.
- Other reasons to draw a random sample include protecting against a bad SRS, lower cost of administering the survey, and ensuring comparable precision of estimates (e.g., of means) within strata.

Cluster Sampling

- We aggregate the observational units into clusters, sample clusters, and then sample all or some observational units within clusters.
- The clusters are called primary sampling units (psu's) and the samples within clusters are called secondary sampling units (ssu's).
- The primary motivation for cluster sampling is to save money when sampling units from a population that is geographically dispersed (like Canada) or naturally grouped into clusters (like schools, or hospitals).

Complex Surveys

- Complex surveys may employ a combination of clustering and stratification.
- Example: The Canadian Community Health Survey – Healthy Aging.
- See the documentation available on canvas.

Demographic and HUI Variables

- Illustrate survey information with a selection of demographic and health-utility-index (HUI) variables.

```
uu<-url("http://people.stat.sfu.ca/~mcneney/Teaching/Stat305/Data/HUI.csv")
hui <- read.csv(uu)
head(hui,n=3)
```

```
##   GEO_PRV  GEOGCMA2        DHHGAGE DHH_SEX          HUIDCOG
## 1     ONT NON - CMA 45 TO 49 YEARS  FEMALE COG. ATT. LEVE 1
## 2     ONT       CMA 55 TO 59 YEARS    MALE COG. ATT. LEVE 1
## 3     ONT       CMA 75 TO 79 YEARS    MALE COG. ATT. LEVE 1
##           HUIGDEX          HUIDEMO     HUIGHER HUIDHSI     HUIGMOB
## 1 USE OF HANDS/F. EMOT. ATT. LEV.1 NO PROBLEMS   0.838 NO PROBLEMS
## 2 USE OF HANDS/F. EMOT. ATT. LEV.1 NO PROBLEMS   0.973 NO PROBLEMS
## 3 USE OF HANDS/F. EMOT. ATT. LEV.1 NO PROBLEMS   0.973 NO PROBLEMS
##       HUIGSPE          HUIGVIS   WTS_M
## 1 NO PROBLEMS VISUAL PROB. COR 1026.07
## 2 NO PROBLEMS VISUAL PROB. COR 1987.81
## 3 NO PROBLEMS VISUAL PROB. COR  343.27
```

```
summary(hui)
```

```
##     GEO_PRV          GEOGCMA2               DHHGAGE       DHH_SEX
##  ONT    :6525   CMA      :17335   55 TO 59 YEARS:4788   FEMALE:17568
##  QUE    :5217   NON - CMA:13530   60 TO 64 YEARS:4542   MALE  :13297
##  BC     :3860                     85 AND OLDER  :4074
##  AB     :2735                     65 TO 69 YEARS:3958
##  NS     :2282                     70 TO 74 YEARS:3017
##  NB     :2225                     75 TO 79 YEARS:2967
##  (Other):8021                     (Other)       :7519
##              HUIDCOG                  HUIGDEX                   HUIDEMO
##  COG. ATT. LEVE 1:21495   LIM. HANDS/F   :  405   EMOT. ATT. LEV.1:22980
##  COG. ATT. LEVE 2:  765   USE OF HANDS/F.:30446   EMOT. ATT. LEV.2: 6342
##  COG. ATT. LEVE 3: 5896   NA's           :   14   EMOT. ATT. LEV.3: 1136
##  COG. ATT. LEVE 4: 1938                           EMOT. ATT. LEV.4:  263
##  COG. ATT. LEVE 5:  641                           EMOT. ATT. LEV.5:   66
##  COG. ATT. LEVE 6:   94                           NA's            :   78
##  NA's            :   36
##             HUIGHER         HUIDHSI                   HUIGMOB
##  NO PROBLEMS    :26706   Min.   :-0.3170   NEED MECH. SUPP: 2454
##  PROB./CORR.    : 2490   1st Qu.: 0.7270   NO AID REQUIRED:  487
##  PROB./NOT CORR.: 1221   Median : 0.9050   NO PROBLEMS    :27007
##  NA's           :  448   Mean   : 0.8057   REQUIRES HELP  :  891
##                          3rd Qu.: 0.9730   NA's           :   26
##                          Max.   : 1.0000
##                          NA's   :759
##              HUIGSPE                 HUIGVIS          WTS_M
##  NO PROBLEMS     :30605   NO PROBLEMS     : 6473   Min.   :   10.00
##  PARTIAL/NOT UND.:  244   VISUAL P. UNCOR.: 1020   1st Qu.:   91.21
##  NA's            :   16   VISUAL PROB. COR:23144   Median :  228.41
##                           NA's            :  228   Mean   :  441.78
##                                                    3rd Qu.:  514.93
##                                                    Max.   :23740.26
##
```

Sampling Weights

- The sampling weight for a sample member is the number of units in the population represented by the sample member.
  - The sampling weight is the inverse of the probability that the sample member was included in the sample.
- For example, if the population has 1600 men and 400 women, and a stratified sample is of 200 men and 200 women, then each sampled man represents 8 and each sampled woman represents 2.
  - Each man has a $1/8$ chance and each woman a $1/2$ chance of being included in the study.
- For complex surveys, determining sampling weights requires specialized expertise.
  - In the CCHS-HA, sampling weights are provided in the `WTS_M` variable.

Sampling Weights for CCHS-HA

```
library(dplyr)
hui %>% group_by(GEO_PRV,GEOGCMA2) %>%
  summarize(Q1=quantile(WTS_M,.25),
            Q2=quantile(WTS_M,.5),
            Q3=quantile(WTS_M,.75))
```

```
## # A tibble: 19 x 5
## # Groups:   GEO_PRV [?]
##    GEO_PRV      GEOGCMA2      Q1    Q2    Q3
##    <fct>        <fct>      <dbl> <dbl> <dbl>
##  1 AB           CMA         146.  300.  525.
##  2 AB           NON - CMA   156.  339.  618.
##  3 BC           CMA         180.  308.  439.
##  4 BC           NON - CMA   197.  386.  650.
##  5 MB           CMA          88.0 152.  226.
##  6 MB           NON - CMA    87.5 156.  263.
##  7 NB           CMA          55.5 104.  158.
##  8 NB           NON - CMA    60.1 111.  171.
##  9 NFLD & LAB.  CMA          43.8  81.8 114.
## 10 NFLD & LAB.  NON - CMA    48.7 101.  133.
## 11 NS           CMA          71.5 124.  187.
## 12 NS           NON - CMA    78.7 135.  200.
## 13 ONT          CMA         290.  536.  792.
## 14 ONT          NON - CMA   314.  570.  903.
## 15 PEI          NON - CMA    13.5  26.5  44.4
```

Sampling Weights by Age

```
hui %>% group_by(DHHGAGE) %>%
  summarize(Q1=quantile(WTS_M,.25),
            Q2=quantile(WTS_M,.5),
            Q3=quantile(WTS_M,.75))
```

```
## # A tibble: 9 x 4
##   DHHGAGE           Q1    Q2    Q3
##   <fct>          <dbl> <dbl> <dbl>
## 1 45 TO 49 YEARS 190.  506.  1192.
## 2 50 TO 54 YEARS 186.  507.  1247.
## 3 55 TO 59 YEARS 133.  301.   573.
## 4 60 TO 64 YEARS 121.  274.   550.
## 5 65 TO 69 YEARS  99.6 232.   456.
## 6 70 TO 74 YEARS 111.  265.   507.
## 7 75 TO 79 YEARS  89.1 213.   396.
## 8 80 TO 84 YEARS  71.0 173.   348.
## 9 85 AND OLDER    28.9  64.5  135.
```

Weighted Means

- The estimate of the population mean from a weighted sample $y_1, \ldots, y_n$ with weights $w_1, \ldots, w_n$ is

$$\frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i}$$

```
hui %>% group_by(DHH_SEX) %>%
  summarize(unwtd.mean=mean(HUIDHSI,na.rm=TRUE),
            wtd.mean=weighted.mean(HUIDHSI,w=WTS_M,na.rm=TRUE))
```

```
## # A tibble: 2 x 3
##   DHH_SEX unwtd.mean wtd.mean
##   <fct>        <dbl>    <dbl>
## 1 FEMALE       0.794    0.838
## 2 MALE         0.822    0.857
```