# Survey Analysis

Adam J Sullivan, PhD

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# Random Sampling

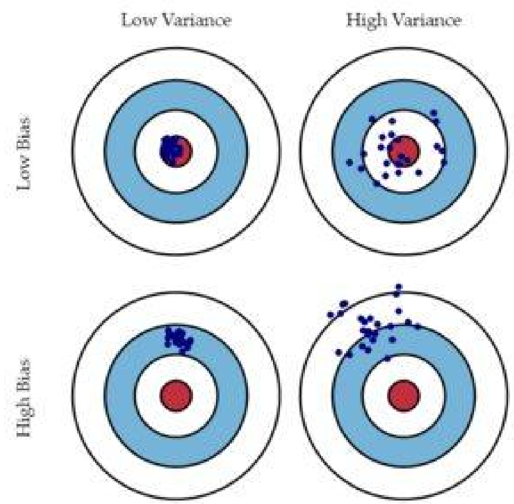
# Random Sampling

- Simple Random Sampling is where each member of the population has the same probability of being sampled.
- The goal is to produce a representative sample that does not have problems with selection bias.

# Sampling Error and Bias

- Sampling error is the inherent error that is a produce of the variation of different samples.
  - Can change with survey design.
  - Clustering and Stratification add further errors and bias in.
- Bias: Difference between estimator's value based on sample and the true value of the population parameter being estimated.
  - An estimate is biased if the of it's distribution is not the population mean.

# Bias Variance Tradeoff



# Why Surveys

# Why Surveys

- Randomly sampling from populations can be extremely expensive
- Many times you also want to guarantee that you reach certain parts of population that you you are concerned about having enough information on.
- We use Surveys to save cost and make sure we hear from specific subpopulations we are interested in.

# Types of Survey Data

- **Stratified Sampling** - Sample across different strata to make representative.
- **Cluster Sampling** - Sample across clusters, for example neighborhoods.
- **Weighted Sampling** - You may choose to oversample from important subpopulations, for example ethnic minorities or impoverished neighborhoods.

# How Does this Change our Analysis?

- We can no longer assume that everyone has an equal probability of being selected.
- We assume that we know a certain probability of being selected, $\pi_i$ for each individual.
- We then need to weight based on this $\pi_i$

# How Does this Change our Anaysis?

- For example if we randomly sample from the population a good estimate for the total sample size is simple

$$T_x = \sum_{i=1}^{N} x_i$$

- For a survey we sampled based on unequal probabilities

$$T_X = \sum_{i=1}^{N} \frac{1}{\pi_i} x_i$$

# What else does this effect?

- We no longer get the correct estimate of variance.
- We need to adjust things like means for the new total population.

# Methods for Variance?

- We could estimate variances using:
  - delta method
  - jackknife
  - bootstrap
  - Other resampling tools

# What Do we Do?

- We can no longer use regular summary, regression or even graphic techniques.
- Each person does not count as 1 anymore in this data.
- Luckily statistical software has been created to deal with these issues.

# What Do we Need to Know?

- Describing your survey design.
- Summary Statistics
- Tables
- Graphics
- Regression Modeling
- Calibration

# The **survey** package in R

# Enter the **survey** Package in R

- The survey package in R has been built to handle survey data.
- It can do all of the procedures above.
- It can also work directly with databases for connecting to surveys stored in databases.

# Describing the Design

```
library(survey)
brfss.design <- svydesign(data=brfss, nest=TRUE,
weight= ~llcpwt,id= ~psu, strata= ~ststr)
```

- `data` the data for your survey.
- `nest` if your data needs to be relabeled due to nesting.
- `weight` weights for the specific sampling.
- `id` unique ids for the sampling groups.
- `strata` strata that weights and ids refer to.

# Enter BRFSS Data

- BRFSS is the Behavioral Risk Factor Surveillance System (BRFSS).
- This is a national health-related telephone survey.
- There are more than 400,000 interviews done every year from all 50 states and the district of Columbia.
- To learn more about this survey please go to their website: Behavioral Risk Factor Surveillance System.

# BRFSS Information

- Codebook
- Data
- Variable Layout

# Reading the Data

```
load("C:/Users/adam_/Dropbox (Personal)/Brown/Teaching/TSHS_Challenge/TSHS_challenge/BRFSS_2014.rda")
names(brfss) <- tolower(names(brfss)) # Make sure they line up with SAS names
names(brfss) <- gsub("x_", "", names(brfss)) # Make sure they line up with SAS names
```

# The Design in R

```
library(survey)
brfss.design <- svydesign(data=brfss_sub_com, nest=TRUE,
                          weight= ~llcpwt,id= ~psu, strata= ~ststr)
```

# What Does this tell us?

```
brfss.design
```

```
## Stratified Independent Sampling design (with replacement)
## svydesign(data = brfss_sub_com, nest = TRUE, weight = ~llcpwt,
##     id = ~psu, strata = ~ststr)
```

# What else can we view?

```
summary(brfss.design)
```

# What else can we view?

```
Stratified Independent Sampling design (with replacement)
svydesign(data = brfss_sub_com, nest = TRUE, weight = ~llcpwt,
    id = ~psu, strata = ~ststr)
Probabilities:
     Min.   1st Qu.    Median      Mean
0.0000346 0.0012320 0.0030010 0.0076400
  3rd Qu.      Max.
0.0071610 0.7931000
Stratum Sizes:
           11011 11012 11021 11022 11031
           11032 11041 11042 11051 11052
           11061 11062 11071 11072 11081
           ...
```

# What else can we view?

```
[ reached getOption("max.print") -- omitted 3 rows ]
Data variables:
 [1] "insurance"      "imprace"
 [3] "pcp"            "education"
 [5] "age"            "annual_income"
 [7] "employed"       "sex"
 [9] "military"       "cost"
[11] "children_count" "llcpwt"
[13] "psu"            "ststr"
```

# Data

```
names(brfss.design)
```

```
## [1] "cluster"    "strata"     "has.strata" "prob"       "allprob"
## [6] "call"       "variables"  "fpc"        "pps"
```

# Basic Summaries: Totals

```
#Sometimes strata only have one person in them
# We need to tell R how to adjust for this
```

```
options(survey.lonely.psu = "adjust")
svytotal(~insurance, brfss.design)
svytotal(~imprace, brfss.design)
```

```
#We could also have this done for more than one
#variable at a time:

svytotal(~insurance + imprace, brfss.design)
```

# Basic Summaries: Totals

```
options(survey.lonely.psu = "adjust")
svytotal(~insurance, brfss.design)
```

```
##                   total     SE
## insuranceNo  13654714 201653
## insuranceYes 65124829 255568
```

# Basic Summaries: Totals

```
options(survey.lonely.psu = "adjust")
svytotal(~imprace, brfss.design)
```

```
##                      total     SE
## impraceWhite    44507752 216030
## impraceBlack    10111446 159564
## impraceAsian     3975911 140229
## impraceAI/AN      866153  37770
## impraceHispanic 17769428 225292
## impraceOther     1548855  49807
```

# Basic Summaries: Totals

```
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```
##                         total     SE
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## impraceOther      1548855  49807
```

# Basic Summaries: Means

```
options(survey.lonely.psu = "adjust")

#Continuous: give means
svymean(~age,brfss.design)

#Categorical: gives proportions
svymean(~insurance, brfss.design)
svymean(~imprace, brfss.design)


#Also with multiple variables
svymean(~age+insurance+imprace, brfss.design)
```

# Basic Summaries: Means

```
##     mean   SE
## age 38.7 0.07
##              mean SE
## insuranceNo  0.173  0
## insuranceYes 0.827  0
##                   mean SE
## impraceWhite    0.5650  0
## impraceBlack    0.1284  0
## impraceAsian    0.0505  0
## impraceAI/AN    0.0110  0
## impraceHispanic 0.2256  0
## impraceOther    0.0197  0
```

# Basic Summaries: Means

```
##                     mean   SE
## age              38.6604 0.07
## insuranceNo       0.1733 0.00
## insuranceYes      0.8267 0.00
## impraceWhite      0.5650 0.00
## impraceBlack      0.1284 0.00
## impraceAsian      0.0505 0.00
## impraceAI/AN      0.0110 0.00
## impraceHispanic   0.2256 0.00
## impraceOther      0.0197 0.00
```

# Basic Summaries: Means

```
##                    mean   SE
## age             38.6604 0.07
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## insuranceYes     0.8267 0.00
## impraceWhite     0.5650 0.00
## impraceBlack     0.1284 0.00
## impraceAsian     0.0505 0.00
## impraceAI/AN     0.0110 0.00
## impraceHispanic  0.2256 0.00
## impraceOther     0.0197 0.00
```

# Basic Summaries: Quantiles

- Necessary for Boxplots

```
options(survey.lonely.psu = "adjust")
svyquantile(~age, brfss.design, c(.25,.5,.75), ci=TRUE)
```

# Basic Summaries: Quantiles

- Necessary for Boxplots

```
## $quantiles
##     0.25 0.5 0.75
## age   30  38   46
##
## $CIs
## , , age
##
##        0.25 0.5 0.75
## (lower   30  38   46
## upper)   31  38   46
```

# Tables in R

- With survey data we would like to be able to have contingency tables as well.
- For example lets say that we want to consider insurance and race:

# Survey Tables in R

```
# This produces a table with the means in one column
a <- svymean(~interaction(insurance, imprace), design = brfss.design)
a

# This produces the table in a contingency table format
b <- ftable(a, rownames = list(insurance = c("No", "Yes"),
      imprace = c("White", "Black", "Asian", "Ai/AN", "Hispanic", "Other")))
b


# we can turn these to percents and round better
round(100*b,2)
```

# Survey Tables in R

```
##                                                      mean SE
## interaction(insurance, imprace)No.White     0.05911  0
## interaction(insurance, imprace)Yes.White    0.50586  0
## interaction(insurance, imprace)No.Black     0.02329  0
## interaction(insurance, imprace)Yes.Black    0.10506  0
## interaction(insurance, imprace)No.Asian     0.00574  0
## interaction(insurance, imprace)Yes.Asian    0.04473  0
## interaction(insurance, imprace)No.AI/AN     0.00167  0
## interaction(insurance, imprace)Yes.AI/AN    0.00932  0
## interaction(insurance, imprace)No.Hispanic  0.08040  0
## interaction(insurance, imprace)Yes.Hispanic 0.14516  0
## interaction(insurance, imprace)No.Other     0.00311  0
## interaction(insurance, imprace)Yes.Other    0.01655  0
```

# Survey Tables in R

```
##                insurance       No      Yes
## imprace
## White    mean           0.059106 0.505860
##          SE             0.001293 0.002744
## Black    mean           0.023290 0.105061
##          SE             0.000984 0.001788
## Asian    mean           0.005744 0.044725
##          SE             0.000705 0.001610
## Ai/AN    mean           0.001675 0.009320
##          SE             0.000200 0.000438
## Hispanic mean           0.080404 0.145155
##          SE             0.001908 0.002295
## Other    mean           0.003110 0.016550
##          SE             0.000273 0.000575
```

# Survey Tables in R

we can turn these to percents and round better

```
##                insurance    No   Yes
## imprace
## White    mean            5.91 50.59
##          SE              0.13  0.27
## Black    mean            2.33 10.51
##          SE              0.10  0.18
## Asian    mean            0.57  4.47
##          SE              0.07  0.16
## Ai/AN    mean            0.17  0.93
##          SE              0.02  0.04
## Hispanic mean            8.04 14.52
##          SE              0.19  0.23
## Other    mean            0.31  1.66
##          SE              0.03  0.06
```

# Chi-SQuare Test Over Table

```
svytable(~insurance+imprace, design=brfss.design)
svychisq(~insurance+imprace, design=brfss.design,
         statistic="Chisq")
```

# Chi-SQuare Test Over Table

```
## Error in onestrat(x[index, , drop = FALSE], clusters[index], nPSU[index][1], : Stratum (22999) has on
```

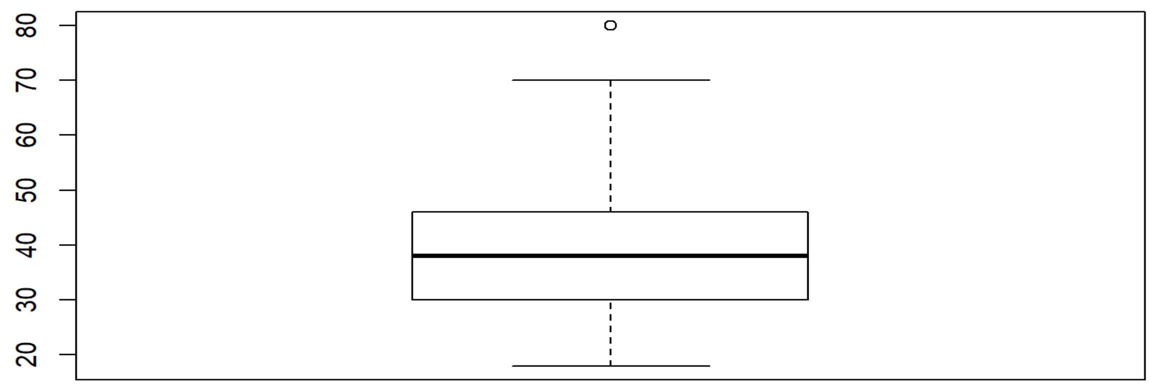
```
##          imprace
## insurance    White    Black    Asian    AI/AN Hispanic    Other
##       No   4656358  1834760   452476   131934  6334172   245014
##       Yes 39851393  8276686  3523435   734219 11435255  1303841
```

# Graphics: Boxplots

```
#Single boxplot
svyboxplot(age~1, brfss.design)

#Boxplot by categorical variable
svyboxplot(age~insurance, brfss.design)
```

# Graphics: Boxplots



# Graphics: Boxplots

```
## Error in onestrat(x[index, , drop = FALSE], clusters[index], nPSU[index][1], : Stratum (22999) has on
```

# Graphics: Histograms

```
svyhist(~age, brfss.design)
```

# Graphics: Histograms

```
## Error in onestrat(x[index, , drop = FALSE], clusters[index], nPSU[index][1], : Stratum (22999) has on
```

# Regressions

- Linear

```
svyglm( outcome ~ covariate1 + covariate2,
  design=brfss.design
```

- Logistic

```
svyglm( outcome ~ covariate1 + covariate2,
  design=brfss.design, family="binomial")
```

- Cox-PH

```
svycoxph( Surv(time,event)~ covariates,
  design=brfss.design)
```