Sample design using the U.S. Census PDB

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Show of hands

1. Name!
2. Where you are from (location and affiliation).
3. The most interesting thing you've learned so far in SPSS.
4. R? Stata? SAS? SPSS? Python? MATLAB?

Outline

1. The U.S. Census Planning Database, U.S. Census geography, race/ethnicity
2. Survey sampling design target
3. Stas' initial attempt
4. Actual workshop -- challenge to improve upon Stas' work!

Libraries

```
libs <- c('tidyverse', 'here', 'knitr', # 'vtable',
          'xaringanthemer', 'kableExtra')
for( l in libs) {
  library(l, character.only = TRUE)
}
```

The best way to proceed with this workshop is:

1. Create a new RStudio project for this workshop in a new folder.
2. Download the .Rmd file from Canvas.
3. Download the .csv file from Canvas into PDB subfolder.
4. Open the .Rmd file and "Run all chunks" from RStudio menu.
5. `install.packages("library_name")` whatever you may be missing.

In Stata, you should be able to read the data file as:

```
import delimited using PDB/pdb2021trv3_ct.csv, clear
```

The U.S. Census Bureau and its data

Planning Databases

https://www.census.gov/topics/research/guidance/planning-databases.2021.html

PDB data

```
if (file.exists(here('PDB','pdb2021trv3_ct.csv'))) {
  PDB_CT <- read_csv(here('PDB','pdb2021trv3_ct.csv'))
} else {
  PDB_US <- read_csv(here('PDB','pdb2021trv3_us.csv'))
}
```

Note to students: the above code uses `library(here)` to create internalized relative links to files within an R/RStudio project. The reference `here('PDB','pdb2021trv3_ct.csv')` will point to the file in the directory `PDB`, i.e., will create a full reference

> `[project root folder]/PDB/pdb2021trv3_ct.csv`

On my computer, this reference is C:/Users/kolenikovs/Projects.2021/UMich.SRS/PDB/pdb2021trv3_ct.csv. On your computer, you would need to save the `.Rmd` file with this presentation and either

- start an RStudio project in that folder, or
- create an empty `.here` file in that same directory so that `library(here)` will pick that up as the starting location.

US Census Tracts

- Tract $\subset$ county $\subset$ state
- Tract population: about 4000

https://www2.census.gov/geo/pdfs/education/CensusTracts.pdf

Example tracts

University of Michigan:

- ACS profile (MCDC)
- Tiger boundaries: https://tigerweb.geo.census.gov/tigerweb/, search for 500 S STATE ST, ANN ARBOR, MI, 48109

Stas' residence:

- ACS profile (MCDC)
- Tiger boundaries: https://tigerweb.geo.census.gov/tigerweb/, search for CT 11.08 COLUMBIA, MO, 65203

Sample design task

Sample design target

We need to create a sample of adults in the state of https://en.wikipedia.org/wiki/Connecticut, with the target of 2500, and oversample targets for racial/ethnic minorities:

- Black/African American: 500
- Hispanic: 500

Simplifications:

- disregard household size distributions between race/ethnicity groups
- disregard the age distributions between race/ethnicity groups

Connecticut

```
if (!exists("PDB_CT")) {
  PDB_US %>% filter(State=='09', !is.na(Tot_Population_ACS_15_19),
                Tot_Population_ACS_15_19 > 0 ) -> PDB_CT
  # export
  write_csv(PDB_CT, here('PDB','pdb2021trv3_ct.csv'))
}
PDB_CT %>%
  group_by(State, State_name) %>%
  summarize(tracts=n(),
    adult_pop = sum( Pop_18_24_ACS_15_19 + Pop_25_44_ACS_15_19 +
                     Pop_45_64_ACS_15_19 + Pop_65plus_ACS_15_19) ) %>%
  maybe_kable()
```

State	State_name	tracts	adult_pop
09	Connecticut	828	2 831 241

Stas' first steps

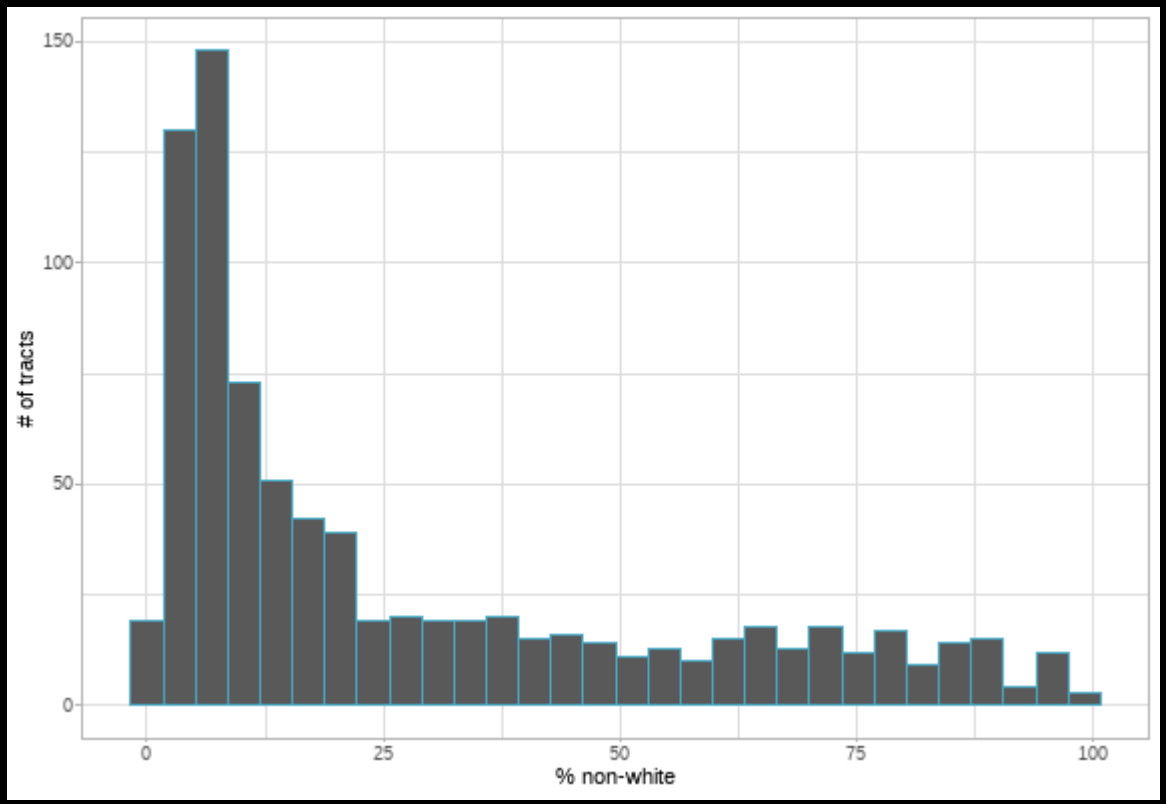
Solution: stratified design

Create several strata and vary sampling rates between them to achieve the target sample sizes.

```
PDB_CT %>% mutate(
  pct_NH_black_alone = NH_Blk_alone_ACS_15_19 / Tot_Population_ACS_15_19,
  pct_hisp           = Hispanic_ACS_15_19 / Tot_Population_ACS_15_19,
  pct_minority       = pct_NH_black_alone + pct_hisp
) -> PDB_CT
ggplot(data=PDB_CT) +
  geom_histogram(aes(x=pct_minority), color='skyblue')
```

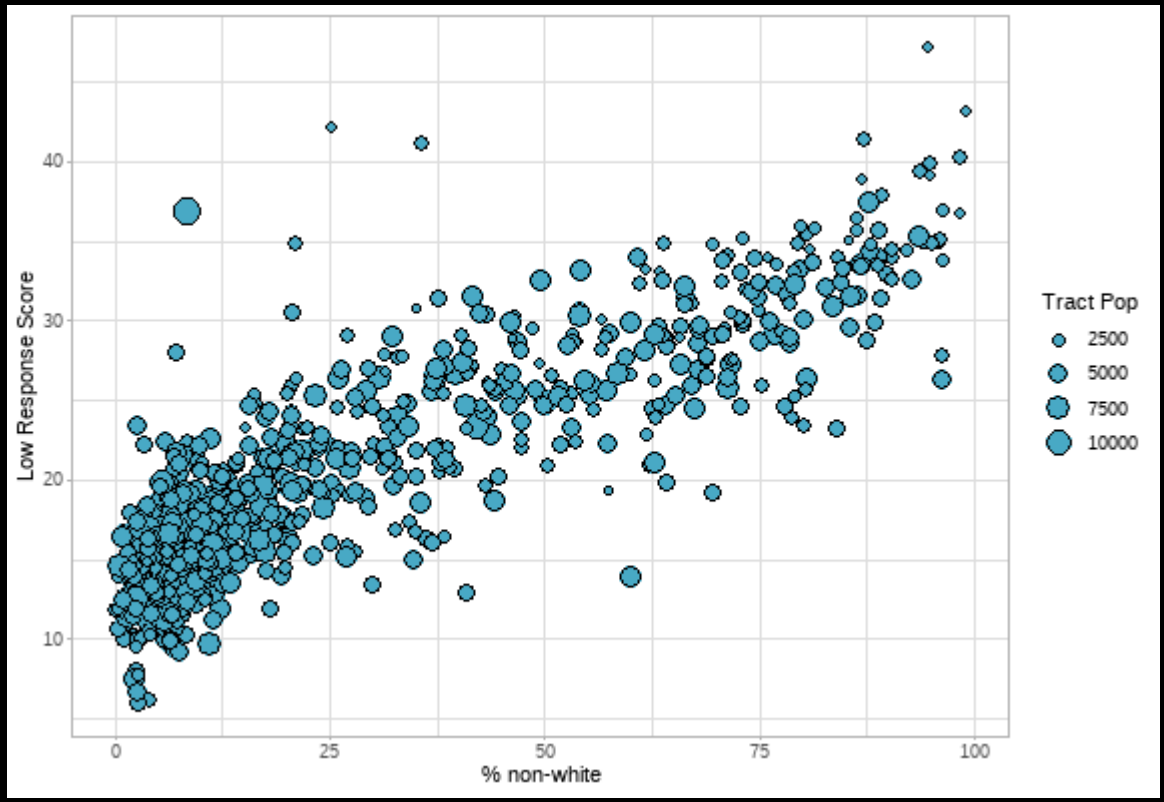
Solution: stratified design

Create several strata and vary sampling rates between them to achieve the target sample sizes.



Beware of nonresponse!

```
ggplot(data=(PDB_CT) +
  geom_point(aes(x=pct_minority,y=Low_Response_Score,
                 size=Tot_Population_ACS_15_19) )
```



Overall anticipated response rate

```
PDB_CT %>% summarize(
  LRS = weighted.mean(x=Low_Response_Score,
                      w=Tot_Population_ACS_15_19,
                      na.rm=TRUE) ) %>%
  select(LRS) %>% unlist() -> LRS
```

The overall, population weighted low response score is 20.0746219.

Thus for the target sample size of 2500, one needs to field about 3128 cases.

Two-strata solution: high vs. low minority tracts

```
PDB_CT %>% mutate(strata2 = if_else(pct_minority > 0.5, 1, 2) ) %>%
  group_by(strata2) %>%
  summarize(
    tract        = n(),
    min_minority = min(pct_minority),
    max_minority = max(pct_minority),
    pop   = sum(Tot_Population_ACS_15_19),
    black = sum(NH_Blk_alone_ACS_15_19),
    hisp  = sum(Hispanic_ACS_15_19),
    RR    = 1 - weighted.mean(x=Low_Response_Score,
                              w=Tot_Population_ACS_15_19,
                              na.rm=TRUE)/100
) -> CT_strata2
```

Two-strata solution: high vs. low minority tracts

```
CT_strata2 %>% kable()
```

strata2	tract	min_minority	max_minority	pop	black	hisp	RR
1	182	0.50134	0.9912892	704 096	213 395	294 119	0.7042099
2	646	0.00000	0.4997575	2 870 978	140 725	280 121	0.8225065

Trial-and-error allocation

Compute anticipated number of Black/AA interviews; number of Hispanic interviews; adjust inputs until the results are acceptable

```
CT_strata2 %>% mutate(
  n_field = case_when(strata2 == 1 ~ 2100, strata2 == 2 ~ 1100),
  n_total = floor(n_field * RR),
  n_black = floor(n_field * RR * black / pop),
  n_hisp  = floor(n_field * RR * hisp / pop),
  sampling_rate = n_field/pop*1e3
) %>% select(strata2, sampling_rate, starts_with('n_')) -> CT_strata2_c
```

strata2	sampling_rate	n_field	n_total	n_black	n_hisp
1	2.9825478	2 100	1 478	448	617
2	0.3831447	1 100	904	44	88

Overall sample size: 2382 vs. 2500, Black AA race and Hispanic ethnicity oversamples of 492 and 705 (vs. target 500 each).

Trial-and-error allocation

Compute anticipated number of Black/AA interviews; number of Hispanic interviews; adjust inputs until the results are acceptable (overall sample size 2500, Black AA race/Hispanic ethnicity oversamples of 500 each).

```
bind_rows( CT_strata2_completes %>% mutate(strata2=as.character(strata2)),
           CT_strata2_completes %>% select(starts_with("n_")) %>%
           summarize_all(sum) %>% mutate(strata2='Total')) %>% kable()
```

strata2	sampling_rate	n_field	n_total	n_black	n_hisp
1	3.0038517	2 115	1 489	451	622
2	0.4284254	1 230	1 011	49	98
Total	NA	3 345	2 500	500	720

Simple weights

```
CT_strata2_completes %>%
  full_join( CT_strata2 %>% select(strata2, pop), by='strata2') %>%
  mutate(weight=pop/n_total) %>%
  select(strata2, n_field, n_total, pop, weight) -> CT_strata2_weights
CT_strata2_weights %>% maybe_kable()
```

strata2	n_field	n_total	pop	weight
1	2 115	1 489	704 096	472.865
2	1 230	1 011	2 870 978	2 839.741

Unequal weighting design effect

Unequal weighting design effect $1 + \mathrm{CV}^2 \equiv 1 + L_{Kish}$ for this design is:

```
(CT_strata2_weights %>%
  summarise( n_wgt = sum(n_total*weight),
             n_wgt2 = sum(n_total*weight*weight),
             n = sum(n_total) ) %>%
  mutate(UWE_DEFF = n_wgt2 * n / (n_wgt*n_wgt) ) %>%
  select(UWE_DEFF) %>% unlist() -> UWE_DEFF2)
```

```
## UWE_DEFF
## 1.659822
```

Can you do better??

Better solutions?

- Better choice of the threshold in a two-strata solution?
- Three strata?
  - two thresholds of minorities, combined?
  - separate thresholds for Black/African Americans vs. Hispanics?
- Four strata?
- Minimize design effect?
- Account for response rates at the tract level?

Your turn now!

Exercise 1

- Breakout Zoom rooms, groups of ~4
- Create a *better* design:
  - the above one had too many Hispanics relative to the target (and relative to SRS; hence losses of efficiency)

Stas' best design has DEFF of about 1.23, but it involved heavy-handed numeric optimization with tons of fiddling with optimization parameters.

Further refinements

- Adult vs. total population
- Language barriers (speak English less than very well)
  - partially incorporated in the Low Response Score
  - limits the covered population
- Residential households (vs. group quarters)
- Vacant housing units
- Lower response rates to non-federal surveys

Exercise 2: adjust response rate

Based on your prior experience / existing literature on the surveys of this kind, you expect the overall response rate to be 15%.

Adjust the parameters of your sampling design that you have produced so far in a way that the state-wide response rate on a SRS will be 15%. The `Low_Response_Score` variable will be informative on the relative performance of the different census tracts, but it would have to be modified so that the anticipated response rates hover around the above target figure. This is an open-ended task: you would need to come up with a (mostly) justifiable approach to the task. (A lot of survey statistics consists of inventing or adjusting things!)

Exercise 3: cost-optimal design

Suppose that you want to enroll more Hispanic respondents to the survey by providing materials in Spanish. Let us use the following assumptions:

- the cost of the mailing increases by a factor of 2;
- the response rate of Hispanic respondents who receive materials in Spanish increases by 50% (e.g. from 10% to 15%);
- the Spanish mail materials are only sent in the stratum with the highest concentration of Hispanic population;
- the available budget allows for the mailing of 24,000 "basic" mail materials in English only.

Objective: adjust the sampling design to maximize the overall effective sample size while maintaining the subpopulation sample sizes of 500 Black/African American respondents and 500 Hispanic respondents.

Does offering the instrument in Spanish really save money?

R Markdown

This is an R Markdown `library(xaringan)` presentation. Markdown is a simple formatting syntax for authoring HTML, PDF, and MS Word documents. For more details on using R Markdown see http://rmarkdown.rstudio.com.

R version: R version 4.0.2 (2020-06-22).

Package versions:

- library(tidyverse): version 1.3.0
- library(here): version 0.1
- library(knitr): version 1.30
- library(xaringanthemer): version 0.3.0
- library(kableExtra): version 1.2.1

The color scheme used is the corporate scheme of Abt Associates.