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Applying Propensity Score Methods to Complex Surveys

Xian Wu
Department of Healthcare Policy & Research
Division of Biostatistics and Epidemiology

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Overview of Propensity Score Methodology

- **Observational studies are an important source of evidence to evaluate treatment effects**
- **Reduces the effects of confounding**

- **Step 1: Estimation of PS**
- **Step2: Use of PS to estimate treatment effects (ATT and ATE)**
  - Matching
  - Weighting
  - Stratification
  - Covariate adjustment in outcome regression models (no longer a best practice)

SAS **PSMATCH Procedure**

The PSMATCH procedure computes propensity scores, which estimate the probability that a subject is assigned to treatment given a set of pretreatment (baseline) covariates. The following methods for using the propensity scores to adjust the data for valid estimation of treatment effect are available:

- Inverse probability of treatment weighting and weighting by the odds.
- Stratification of observations that have similar propensity scores. In a subsequent outcome analysis, the treatment effect can be estimated within each stratum, and the estimates can be combined across strata to compute an average treatment effect.
- Matching treated unit with one or more control units that have a similar value of the propensity score.

  Methods of matching include:
  - fixed ratio matching
  - variable ratio matching
  - full matching

Provides various plots for assessing balance. Included plots are:

- cloud plots, which are scatter plots in which the points are jittered to prevent overplotting
- box plots for continuous variables
- bar charts for classification variables
- a standardized differences plot that summarizes differences between the treated and control groups

The PSMATCH procedures saves propensity scores and weights in an output data set that contains a sample that has been adjusted either by weighting, stratification, or matching. If the sample is stratified, you can save the strata identification in the output data set. If the sample is matched, you can save the matching identification in the output data set.

Complex survey data

Survey samples with complex survey designs offer researchers the ability to estimate effects that are generalizable to the target population (often, the national population)

Examples of national survey

- National Health and Nutrition Examination Survey (NHANES)
- National Ambulatory Medical Care Survey (NAMCS)
- National Hospital Ambulatory Medical Care Survey (NHAMCS)
- National Hospital Discharge Survey (NHDS)
- National Home and Hospice Care Survey (NHHCS)
- National Nursing Home Survey (NNHS)
- National Survey of Ambulatory Surgery (NSAS)
- National Employer Health Insurance Survey (NEHIS)
- National Vital Statistics System (NVSS)
- National Health Interview Survey (NHIS)

Complex sample designs

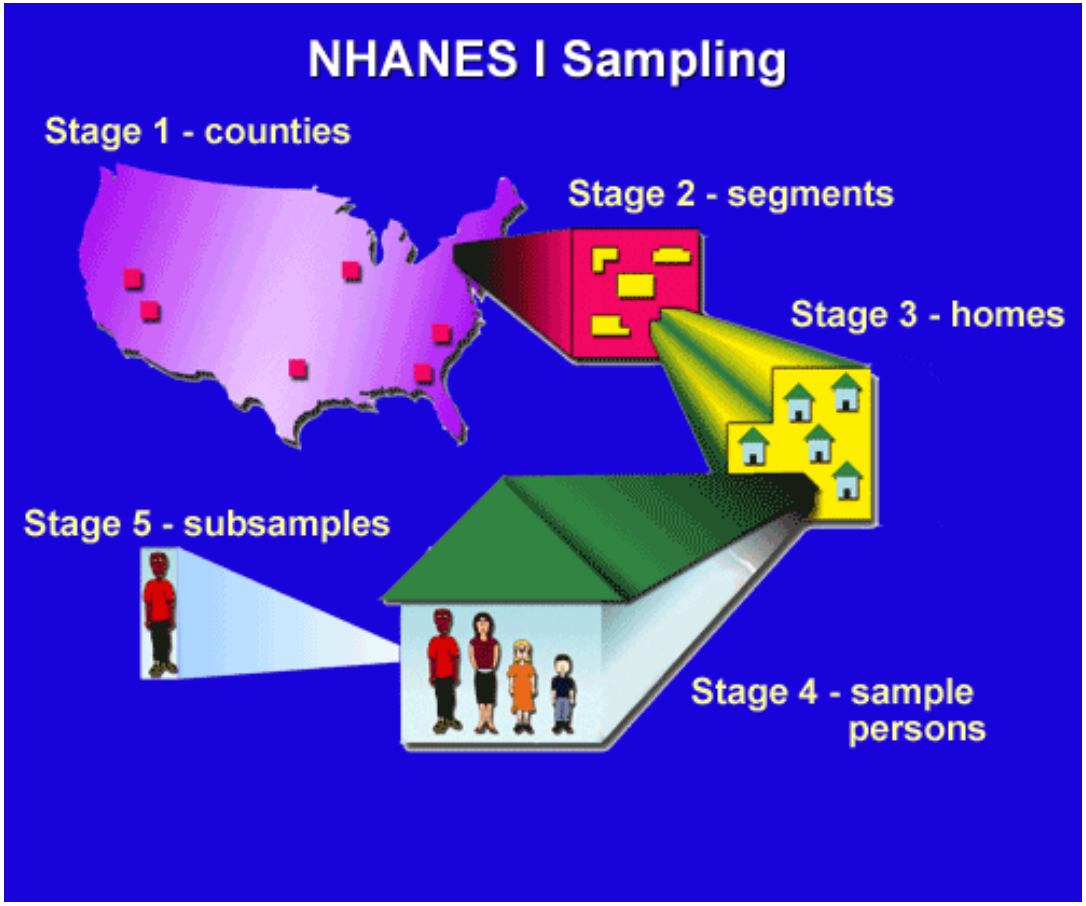
- **stratified designs (sample from each strata)**
- **cluster designs (elements are selected in clusters)**
- **mixed mode designs**

- **Selection weight: used to adjust for differing probabilities of selection**

- **Complex designs with clustering and unequal selection probabilities generally increase the sampling variance**

- **Not accounting for the impact of complex sample design can lead to biased estimates**

National Health and Nutrition Examination Survey (NHANES)



Sample SAS code

the Healthcare Cost and Utilization Project (HCUP) databases

SAS

```
/* Specify the sampling design with sampling weights DISCWT,    */
/*   hospital clusters HOSP_NRD and stratification NRD_STRATUM */
/* Calculate national estimates */
proc surveymeans data = sasdata.readmissions_sql sumwgt sum mean ;
    cluster HOSP_NRD ;
    strata NRD_STRATUM ;
    weight DISCWT ;
    var Readmit ;
    /* We can subset the survey design object so that the target of */
    /* inference is the population of AMI index events only         */
    domain IndexEvent;
    ods output domain = readmissionRates ;
    format IndexEvent indexEvent. ;
run;
```

Sample R code

R

```
install.packages("survey"); library(survey)
# Specify the sampling design with sampling weights DISCWT,
#   hospital clusters HOSP_NRD, and stratification NRD_STRATUM
strnrddsgn <- svydesign(ids = ~HOSP_NRD, weights = ~DISCWT,
      strata = ~NRD_STRATUM, data = core)

# Calculate national estimates
svytotal(~readmit, strnrddsgn)
svymean(~readmit, strnrddsgn)

# We can subset the survey design object so that the target of
#   inference is the population of AMI index events only
strnrddsgn.sub <- subset(strnrddsgn, IndexEvent)
svytotal(~readmit, strnrddsgn.sub)
svymean(~readmit, strnrddsgn.sub)
```

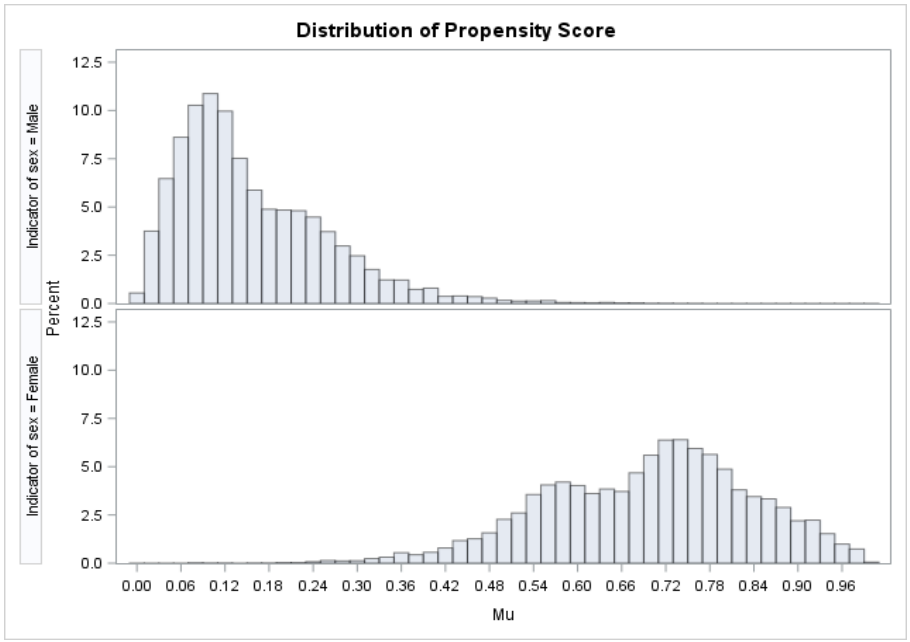
Incorporate survey elements with PS methods

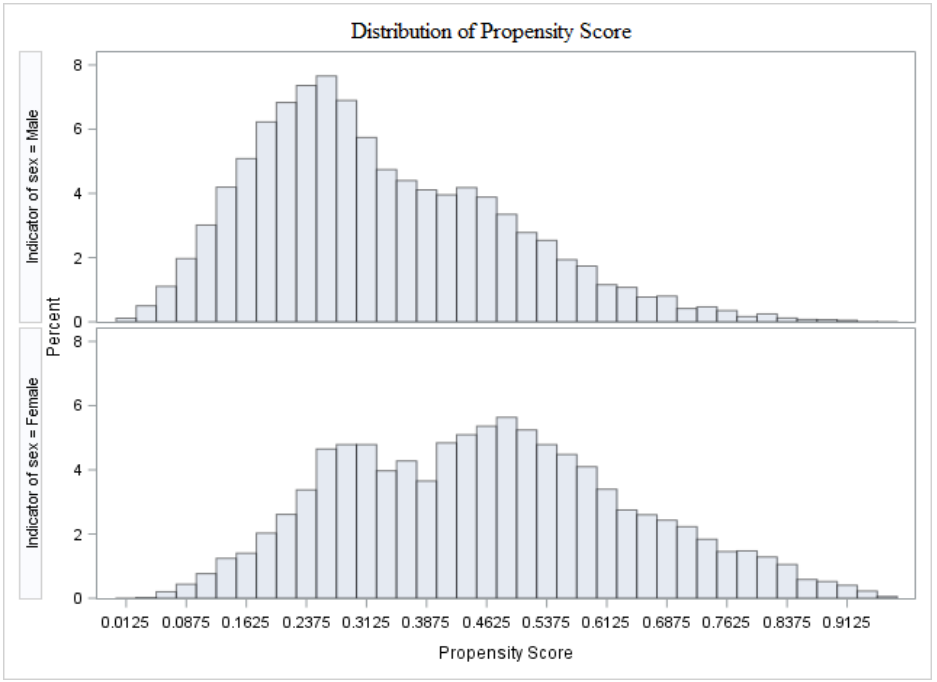
Step 1: Estimation of PS

- Ideally we might include all the survey elements in the propensity score model, but this is not always feasible
- In particular, the survey weight may by particularly important

- **Recommendation:** including the survey weight as a predictor in the propensity score model

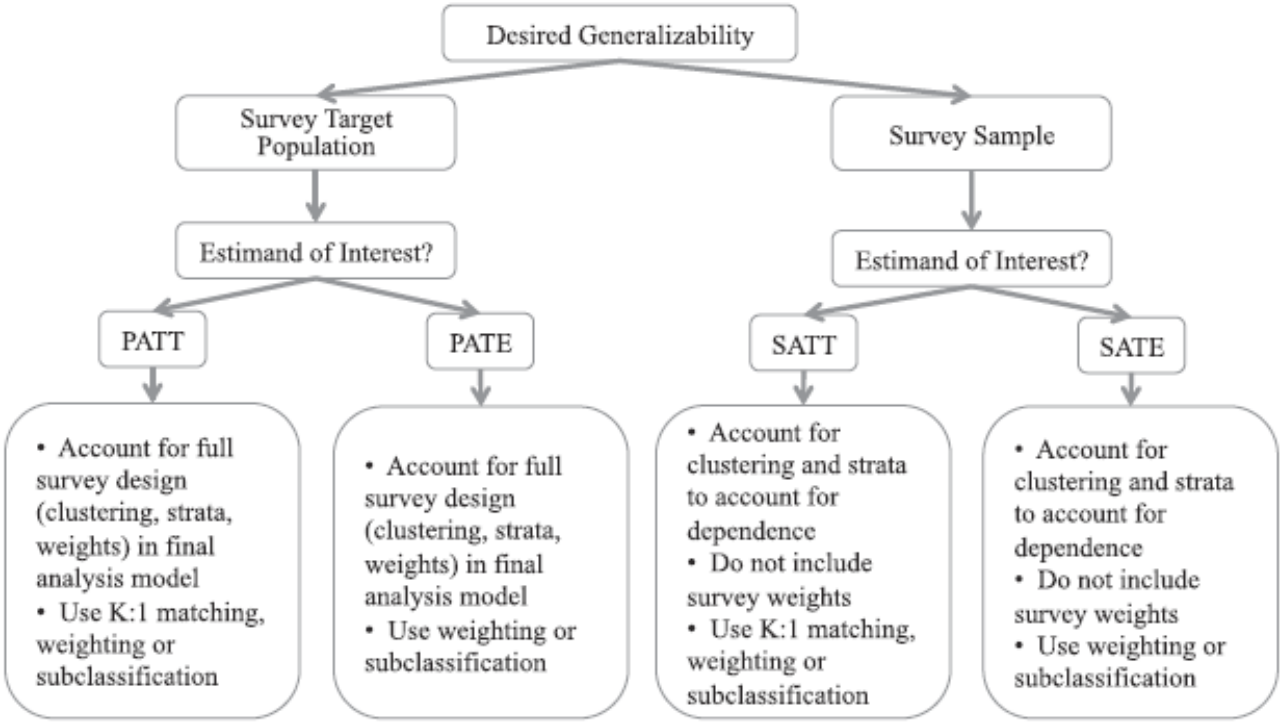
- Whether the propensity score model needs to be a weighted regression or account for the complex survey design
  - not interested in generalizing the PS model to the population
  - not use the variance estimates from the PS model


Distribution of Propensity Score
Indicator of sex = Male
Indicator of sex = Female
Percent
12.5
10.0
7.5
5.0
2.5
0.0
0.00 0.06 0.12 0.18 0.24 0.30 0.36 0.42 0.48 0.54 0.60 0.66 0.72 0.78 0.84 0.90 0.96
Mu


Distribution of Propensity Score
Indicator of sex = Male
Indicator of sex = Female
Percent
8
6
4
2
0
0.0125 0.0875 0.1625 0.2375 0.3125 0.3875 0.4625 0.5375 0.6125 0.6875 0.7625 0.8375 0.9125
Propensity Score

Incorporate survey design elements in the final outcome model

Figure 1: Recommended Decision Tree for Researchers Interested in Causal Estimand Using Complex Survey Data



DuGoff E.H., Schuler M., Stuart E.A. (2014). Generalizing Observational study Results: Applying Propensity Score Methods to Complex Surveys. Health Serv Res

Incorporate survey design elements in the final outcome model

- **Matching:** generate the effect estimate from a survey-weighted regression that accounts for the complex survey design within the matched sample

- **Stratification:** generate the stratum-specific effect estimates from a survey-weighted regression that accounts for the complex survey design within each stratum. The stratum-specific effect estimates are then combined using the survey-weighted stratum size

- **Weighting:** the new weight is the PS weights multiplying survey weights; the effect estimate is generated from a weighted regression that incorporates the complex survey design elements and the composite weight (Cook et al. 2009)

Suggestion:

1. **Researchers should decide if they are interested in the ATE or the ATT**

2. **Researchers must identify to which group (i.e. the target population of the original survey, the survey sample itself, or some other subgroup) they would like to generalize their effect estimates**

3. **Survey weights should be used as a predictor in the PS model. Ideally, including strata, clustering and primary sampling unit information if available and feasible**

4. **An appropriate PS method should be selected**

5. **Be precise when interpreting the study results**

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