Evaluation of Strategies to Improve the Utility of Estimates from a Non-Probability Based Survey

Presenter: Benmei Liu, National Cancer Institute, NIH
liub2@mail.nih.gov

Authors: (Next Slide)

2015 FCSM Research Conference
December 1, 2015
Authors (Alphabetic order): A Multi-Agency, Multi-Disciplinary Effort

- **National Cancer Institute (NCI), Division of Cancer Control and Population Sciences**: Erin Kent, Benmei Liu, Janet S. de Moor, Gordon Willis, Maggie Wilson, K. Robin Yabroff

- **Agency for Healthcare Research and Quality (AHRQ)**: Sadeq R. Chowdhury

- **LIVESTRONG Foundation**: Stephanie Nutt

- **Centers for Disease Control and Prevention (CDC), Division of Cancer Prevention and Control**: Donatus Ekwueme, Juan Rodriguez

- **Emory University**: Katherine S. Virgo
Research goal: empirically examine the impact of applying weight adjustments to non-probability-based survey data and compare results to those obtained from a probability-based survey based on a similar questionnaire.
Data Source #1: Probability Sample

- 2011 Medical Expenditure Panel Survey (MEPS) Experiences with Cancer follow-back survey (CSAQ)
  - Self-administered (paper-based) supplement to the core MEPS
  - Representative of (18+) US non-institutionalized household population of cancer survivors
  - MEPS full year RR=54.9%; CSAQ RR=90%
  - Analytic sample: n = 1,203
Data Source #2: Non-probability Sample

- **2012 LIVESTRONG Survey**
  - Same questionnaire as MEPS CSAQ
  - Web-based, opt-in, available to cancer survivors via email, social media and newsletters
  - Analytic sample (U.S. residents aged 18+ who had ever been diagnosed with cancer at or after age of 17): n= 5,394

*Response rate is undefined*
Different Weighting Approaches for the LIVESTRONG Sample

• Unweighted

• Sample-based Raking: Adjust LIVESTRONG data to distribution of demographic or other characteristics from MEPS CSAQ

• Propensity Score Adjustment (PSA): Weight data by inverse of estimated propensity to be in the LIVESTRONG sample relative to MEPS (Lee, 2006)

• PSA + Raking: PSA first, then raking (Lee and Valiant 2009, Brick 2015)
Choices of Weighting Variables

- **Four** key demographic variables: Age, sex, race/ethnicity, region (same variables used in the core MEPS raking)
- Additional **five** socio-demographic variables: education, marital status, current employment status, cancer type, years from first diagnosis
- Raking dimensions were formed using either
  - the four single variables; or
  - the nine single variables; or
  - the intersection of age by other variables (e.g., age*sex, age*race/ethnicity, age*sex*employment, etc.)
Table 1a: Estimates for Variables used in Weighting*

<table>
<thead>
<tr>
<th></th>
<th>Probability: MEPS CSAQ</th>
<th>Non-Probability: LIVESTRONG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n=1,203</td>
<td>Weighted</td>
</tr>
<tr>
<td><strong>Age</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-49</td>
<td>175</td>
<td><strong>13.1</strong></td>
</tr>
<tr>
<td>50-64</td>
<td>390</td>
<td><strong>32.3</strong></td>
</tr>
<tr>
<td>65+</td>
<td>638</td>
<td><strong>54.6</strong></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>468</td>
<td><strong>42.5</strong></td>
</tr>
<tr>
<td>Female</td>
<td>735</td>
<td><strong>57.5</strong></td>
</tr>
<tr>
<td><strong>Region</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>185</td>
<td><strong>16.9</strong></td>
</tr>
<tr>
<td>Midwest</td>
<td>294</td>
<td><strong>23.2</strong></td>
</tr>
<tr>
<td>South</td>
<td>475</td>
<td><strong>40.7</strong></td>
</tr>
<tr>
<td>West</td>
<td>249</td>
<td><strong>19.2</strong></td>
</tr>
<tr>
<td><strong>Race/Ethnicity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic, NH black, NH Asian</td>
<td>273</td>
<td><strong>12.9</strong></td>
</tr>
<tr>
<td>Other</td>
<td>930</td>
<td><strong>87.1</strong></td>
</tr>
</tbody>
</table>

* “PSA+Raking” method gave the same estimates as “Raking” alone for the variables used in weighting
Table 1b: Estimates for Variables used in Weighting*

<table>
<thead>
<tr>
<th>Probability: MEPS CSAQ</th>
<th>LIVESTRONG</th>
</tr>
</thead>
<tbody>
<tr>
<td>n=1,203</td>
<td>n=5,394</td>
</tr>
<tr>
<td>n</td>
<td>%</td>
</tr>
<tr>
<td>Education</td>
<td></td>
</tr>
<tr>
<td>High school or less</td>
<td>606</td>
</tr>
<tr>
<td>Some college or more</td>
<td>597</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>641</td>
</tr>
<tr>
<td>Not married</td>
<td>562</td>
</tr>
<tr>
<td>Current Employment Status</td>
<td></td>
</tr>
<tr>
<td>Full-time</td>
<td>302</td>
</tr>
<tr>
<td>Part-time</td>
<td>105</td>
</tr>
<tr>
<td>Retired</td>
<td>380</td>
</tr>
<tr>
<td>Not employed for wages / Other</td>
<td></td>
</tr>
<tr>
<td>Cancer Type</td>
<td></td>
</tr>
<tr>
<td>Breast</td>
<td>235</td>
</tr>
<tr>
<td>Prostate</td>
<td>159</td>
</tr>
<tr>
<td>Colorectal</td>
<td>59</td>
</tr>
<tr>
<td>Multiple</td>
<td>86</td>
</tr>
<tr>
<td>Other single cancers</td>
<td>664</td>
</tr>
<tr>
<td>Years from First Cancer DX</td>
<td></td>
</tr>
<tr>
<td>&lt;2</td>
<td>129</td>
</tr>
<tr>
<td>2-5</td>
<td>291</td>
</tr>
<tr>
<td>6-10</td>
<td>236</td>
</tr>
<tr>
<td>11+</td>
<td>547</td>
</tr>
</tbody>
</table>

*“PSA+Raking” method gave the same estimates as “Raking” alone for the variables used in weighting
Major Outcomes of Interest
(11 binary outcomes in total)

• Employment changes (5 outcomes)
  – Made work changes since cancer diagnosis (composite measure)
  – Took extended paid time off from work because of cancer
  – Took unpaid time off from work because of cancer
  – Changed from working full-time to part-time because of cancer
  – Changed from working part-time to full-time because of cancer

• Financial Burden (6 outcomes)
  – Financial impact because of cancer (composite measure)
  – Had to borrow money or go into debt because of cancer
  – Ever filed for bankruptcy because of cancer
  – Made other financial sacrifices because of cancer
  – Ever unable to cover share of cancer medical costs
  – Ever worry about paying medical bills related to cancer
Estimates: Employment Changes and Financial Burden (11 outcomes)

Different weighting using Age, Sex, Race/Ethnicity, Region

Black diamonds: unweighted; Red dots: weighted

- All the red points are expected to be on the diagonal if a weighting method works perfectly.
Estimates: Employment Changes and Financial Burden (11 Outcomes)

Different weighting using Age, Sex, Race/Ethnicity, Region + Five Other Variables*

- Unweighted
- PSA - 9 vars
- Raking - 9 vars
- PSA+Raking - 9 vars

*Five variables:
- Education
- Marital status
- Employment status
- Cancer type
- Years from 1st DX

Black diamond: unweighted; Red dots: weighted

- All the red points are expected to be on the diagonal if a weighting method works perfectly
Estimates: Employment Changes and Financial Impacts (11 Outcomes)

Different Raking Variables/Dimensions

6 dimensions:
- age*sex
- Age*raceethnic
- Age*region
- Age*employment
- Age*sex*employment
- Age*marital status

Additional 3 dimensions:
- Age*education
- Age*cancer type
- Age*yrs since DX

All the red points are expected to be on the diagonal if a weighting method works perfectly
Run Multivariate logistic regression models

- Two outcomes:
  - Any financial Impact due to cancer
  - Any work change due to cancer

- Predictors included:
  - Age(3), Sex(2), Education(2), Race/ethnicity(2), Marital Status(2), Region(4), Years from Cancer Diagnosis(4)
  - Degrees of freedom: 12

- Unweighted and weighted using different set of weights
Table 2: Association Between Variables: Adjusted ORs
Dependent Variable: Any financial Impact due to cancer

<table>
<thead>
<tr>
<th>Respondent characteristics</th>
<th>MEPS (n=1,203)</th>
<th>LIVESTRONG (n=5,394)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Weighted (95% CI)</td>
<td>Unweighted (95% CI)</td>
</tr>
<tr>
<td>Age group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18-49</td>
<td>3.41 (2.14 - 5.41)</td>
<td>4.13 (3.44 - 4.96)</td>
</tr>
<tr>
<td>50-64</td>
<td>1.73 (1.19 - 2.54)</td>
<td>2.68 (2.24 - 3.19)</td>
</tr>
<tr>
<td>65+</td>
<td>REF</td>
<td>REF</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>REF</td>
<td>REF</td>
</tr>
<tr>
<td>Female</td>
<td>1.38 (0.93 - 2.05)</td>
<td>1.27 (1.13 - 1.43)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school graduate or less</td>
<td>1.04 (0.72 - 1.51)</td>
<td>1.44 (1.16 - 1.77)</td>
</tr>
<tr>
<td>Some college or more</td>
<td>REF</td>
<td>REF</td>
</tr>
<tr>
<td>Race/Ethnicity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic, NH black, NH Asian</td>
<td>2.21 (1.51 - 3.23)</td>
<td>1.23 (1.00 - 1.53)</td>
</tr>
<tr>
<td>Other</td>
<td>REF</td>
<td>REF</td>
</tr>
<tr>
<td>Marital Status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Married</td>
<td>REF</td>
<td>REF</td>
</tr>
<tr>
<td>Not married</td>
<td>1.27 (0.90 - 1.79)</td>
<td>1.46 (1.29 - 1.65)</td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Northeast</td>
<td>REF</td>
<td>REF</td>
</tr>
<tr>
<td>Midwest</td>
<td>1.66 (0.85 - 3.26)</td>
<td>1.14 (0.96 - 1.35)</td>
</tr>
<tr>
<td>South</td>
<td>2.01 (1.11 - 3.65)</td>
<td>1.54 (1.31 - 1.81)</td>
</tr>
<tr>
<td>West</td>
<td>2.05 (1.05 - 4.02)</td>
<td>1.40 (1.19 - 1.65)</td>
</tr>
<tr>
<td>Years from First Cancer DX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;2</td>
<td>1.69 (0.99 - 2.88)</td>
<td>1.05 (0.88 - 1.25)</td>
</tr>
<tr>
<td>2-5</td>
<td>1.55 (1.06 - 2.27)</td>
<td>1.05 (0.90 - 1.23)</td>
</tr>
<tr>
<td>6-10</td>
<td>1.37 (0.86 - 2.20)</td>
<td>1.10 (0.93 - 1.31)</td>
</tr>
<tr>
<td>11+</td>
<td>REF</td>
<td>REF</td>
</tr>
</tbody>
</table>
Association Between Variables: Adjusted ORs

Dependent Variable: Any financial Impact due to cancer

Different weighting using Age, Sex, Race/Ethnicity, Region

Unweighted

LS estimated OR

MEPS estimated OR

PSA - 4 vars

LS estimated OR

MEPS estimated OR

Raking - 4 vars

LS estimated OR

MEPS estimated OR

PSA+Raking - 4 vars

LS estimated OR

MEPS estimated OR

Black diamond: unweighted; Red dot: weighted

- All the red points are expected to be on the diagonal if a weighting method works perfectly
Association Between Variables: Adjusted ORs

Dependent Variable: Any financial Impact due to cancer

Different weighting using Age, Sex, Race/Ethnicity, Region + Five Other Variables*

Unweighted

LS estimated OR

MEPS estimated OR

PSA - 9 vars

LS estimated OR

MEPS estimated OR

Raking - 9 vars

LS estimated OR

MEPS estimated OR

PSA+Raking - 9 vars

LS estimated OR

MEPS estimated OR

*Five variables:
  ▪ Education
  ▪ Marital status
  ▪ Employment status
  ▪ Cancer type
  ▪ Years from 1st DX

Black diamond: unweighted; Red dot: weighted

All the red points are expected to be on the diagonal if a weighting method works perfectly
Association Between Variables: Adjusted ORs

Dependent Variable: Any financial Impact due to cancer

Different Raking Variables/Dimensions

Raking - 4 vars

MEPS estimated OR

LS estimated OR

Raking - 9 vars

MEPS estimated OR

LS estimated OR

Raking - 6 dims

MEPS estimated OR

LS estimated OR

Raking - 9 dims

MEPS estimated OR

LS estimated OR

6 dimensions:

age*sex
Age*raceethnic
Age*region
Age*employment
Age*sex*employment
Age*marital status

Additional 3 dimensions:

Age*education
Age*cancer type
Age*yrs since DX

Black diamond: unweighted; Red dot: weighted

- All the red points are expected to be on the diagonal if a weighting method works perfectly
Summary and Discussion

For estimation of (absolute) population quantities:
- For our measures of financial burden and employment, estimates from LIVESTRONG non-probability sample, even weighted, were generally not ‘close’ to those of the MEPS-CSAQ probability sample.

For associations (relative measures):
- Analysis of associations, via regression analysis, illustrated more similarity between surveys irrespective of weighting methods or no weighting.

Overall:
- Bias due to non-probability sampling may be more of a problem for quantity estimation.
• Raking is more efficient than the propensity score weighting approach in terms of reducing bias
• The composite approach (PSA first then raking) may give similar results as raking alone
• Weighting variables and raking dimensions need to be carefully chosen, weighting may introduce more bias depending on the set of weighting variables used
• Raking with carefully chosen variables helps reduce some bias, but not a lot
Limitations

- **Mode confounding?** MEPS-CSAQ was paper-based, LIVESTRONG a web survey
- **MEPS contains sampling error**
  - Implication for control totals (adding additional variances to the LIVESTRONG weighted estimates)
  - Some cell sizes are very small
  - Challenges in variance estimation


Any Questions?

Thank you!

Contact info:
Benmei Liu
liub2@mail.nih.gov