An Assessment of Interrupted Telephone Service Adjustment (ITSA) in Random Digit Dialing (RDD) Telephone Surveys

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turning knowledge into practice

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Agenda

- Nature of the Problem
- Existing Research
- Survey Data Used for Evaluation of the Proposed Solution
- Proposed Solution
- Evaluation of the Proposed Solution
- Summary & Conclusions
Nature of the Problem

Average and maximum percent nontelephone households by household income (CPS 2002)

Percent nontelephone households

Household Income ($000)

0% 10% 20% 30% 40%

Average

Maximum

0 to 15 16.1% 9.1%
15 to 25 6.0% 13.7%
25 to 35 3.6% 10.1%
35 to 50 2.1% 5.1%
50 to 75 0.9% 3.5%
75 and over 0.7% 6.5%
All income 4.5% 9.1%
Nature of the Problem

Percent households without telephone by the Census division (CPS 2002)
Existing Research

- Literature promoting an *ITSA* type procedures first appeared in an article by Keeter (1995), suggesting the use telephone service interruption as a surrogate for lack of telephone service.

- Frankel et. al. (1998) indicates that *ITSA* methodology can reduce the bias due to telephone noncoverage.

- Brick, et. al. (1996) seems to offer a less enthusiastic support for the general utility of this type of adjustment for all RDD surveys.

- Cautious endorsements for using an adjustment of this form for survey estimates that are socioeconomic related.
Behavioral Risk Factor Surveillance System (BRFSS)

- Coordinated by the Centers for Disease Control and Prevention and all state health departments, employs the world’s largest RDD survey.

- In 2002 the sample sizes ranged from 2,408 in the District of Columbia to 13,491 in Pennsylvania, with a median state sample size of 4,401.

- Survey data are weighted to account for oversampling of listed telephone numbers, households with multiple telephone lines, and subsampling of adults in each household.

- Moreover, the resulting base weights are post-stratified to CPS counts within age, gender, and race/ethnicity cells for each state.
The Big Question

Is the gain in bias reduction worth the variance inflation when applying ITSA?
Justification/Application

- BRFSS is uniquely qualified for ITSA, since this survey focuses on risk factors and prevalence estimates for disease, both of which are highly related to the socioeconomic status of individuals.

- For illustration purposes, use will be made of the BRFSS:03 survey data to assess the bias reduction capability of this methodology against the potential loss in precision that will result from variance inflations.
Notation

\[ W_{ijk}^B \] Base weight for the \( k^{th} \) respondent in the \( i^{th} \) state and \( j^{th} \) household income category

\[ W_{ijk}^P \] Post-stratified weight for the \( k^{th} \) respondent in the \( ij^{th} \) cell based on the 2003 methodology

\( n_{ij} \) Number of respondents in the \( ij^{th} \) cell

\( I_{ij} \) Subset of respondents in the \( ij^{th} \) cell with telephone service interruptions

\( N_{ij}^T \) Number of adults in telephone households in the \( ij^{th} \) cell

\( N_{ij}^\bar{T} \) Number of adults in non-telephone households in the \( ij^{th} \) cell

\( N_{ij}^I \) Number of adults in households with telephone service interruptions in the \( ij^{th} \) cell

\( N_{ij}^\bar{I} \) Number of adults in households with no telephone service interruptions in the \( ij^{th} \) cell
Ingredients

- Unfortunately, none of the above four population numbers are readily known.

- However, the first two can be estimated from the CPS:

\[ N_{ij}^T \approx \hat{N}_{ij}^T \]
Ingredients

The latter two can be estimated from the survey data:

\[
N_{ij}^I \approx \hat{N}_{ij}^I = \hat{N}_{ij}^T \left( 1 - \frac{\sum_{k \in I_{ij}} \sum_{w=1}^{n_{ij}} W_{ijk}^P}{\sum_{k=1}^{n_{ij}} \sum_{w=1}^{n_{ij}} W_{ijk}^P} \right) = \hat{N}_{ij}^T \times \frac{\sum_{k \not\in I_{ij}} \sum_{w=1}^{n_{ij}} W_{ijk}^P}{\sum_{k=1}^{n_{ij}} \sum_{w=1}^{n_{ij}} W_{ijk}^P}
\]

\[
N_{ij}^I \approx \hat{N}_{ij}^I = \hat{N}_{ij}^T \left( \frac{\sum_{k \in I_{ij}} \sum_{w=1}^{n_{ij}} W_{ijk}^P}{\sum_{k=1}^{n_{ij}} \sum_{w=1}^{n_{ij}} W_{ijk}^P} \right) = \hat{N}_{ij}^T - \hat{N}_{ij}^I
\]
ITSA Methodology

- Design weight of all respondents are adjusted for telephone non-coverage by:

\[
\begin{align*}
\omega_{ijk}^A &= \left\{ \begin{array}{ll}
\omega_{ijk}^B \times \frac{\hat{N}_{ij}^I + \hat{N}_{ij}^T}{\sum_{k \in I_{ij}} \omega_{ijk}^B}, & \forall k \in I_{ij} \\
\omega_{ijk}^B \times \frac{\hat{N}_{ij}^\bar{I}}{\sum_{k \notin I_{ij}} \omega_{ijk}^B}, & \forall k \notin I_{ij}
\end{array} \right. \\
\end{align*}
\]

- The resulting weights are pos-stratified to CPS counts
Evaluation

- Does the resulting inflation in variance of survey estimates due to this adjustment outweigh the gain in bias reduction?

- Inflation in variances due to unequal weighting effect (UWE) can be approximated by:

\[
UWE = 1 + \left[ CV(w_i) \right]^2 = 1 + \frac{\sum_i (w_i - \bar{w})^2}{n - 1} \frac{1}{\bar{w}^2}
\]
Evaluation
(UWE ratios under ITSA and standard weighting methodologies by state)

- As expected, the variability in weights increases, as all calculated ratios are greater than one.

- The average UWE across all states for the standard methodology is 1.63 while that for the ITSA methodology is 1.70, with an average ratio of 1.04.
Evaluation

A more telling indicator that takes into account the negative effect of variance inflation as well as the positive gain due to bias reduction is Mean Square Ratio (MSR):

\[
MSR(\hat{p}) = \frac{MSE(\hat{p}_{ITSA})}{MSE(\hat{p}_{Old})}
\]

Assuming that the bias reduction under the ITSA methodology will render the resulting point estimate unbiased, then:

\[
MSR(\hat{p}) = \frac{V(\hat{p}_{ITSA})}{V(\hat{p}_{Old}) + (\hat{p}_{Old} - \hat{p}_{ITSA})^2}
\]
## Evaluation (Key outcome measures)

<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Variable</th>
</tr>
</thead>
<tbody>
<tr>
<td>General health status</td>
<td>GOODHLTH</td>
</tr>
<tr>
<td>Any kind of health care coverage</td>
<td>HLTHCOV</td>
</tr>
<tr>
<td>Cost prevented dr. Visit, past 12 months</td>
<td>COSTPREV</td>
</tr>
<tr>
<td>Any exercise, past month</td>
<td>EXERCISE</td>
</tr>
<tr>
<td>Diagnosed diabetes, excluding pregnancy</td>
<td>EVERDIAB</td>
</tr>
<tr>
<td>Diagnosed high blood pressure, excluding pregnancy</td>
<td>EVERBP</td>
</tr>
<tr>
<td>Diagnosed high blood pressure, excluding pregnancy, and currently taking medicine</td>
<td>CURBPMED</td>
</tr>
<tr>
<td>Ever had blood cholesterol checked</td>
<td>BP</td>
</tr>
<tr>
<td>Currently trying to lose weight</td>
<td>CURLOSEW</td>
</tr>
<tr>
<td>Currently have asthma, Dr. Diagnosed</td>
<td>CURASTH</td>
</tr>
<tr>
<td>Had flu shot, past 12 months</td>
<td>FLU</td>
</tr>
<tr>
<td>Ever had pneumonia shot, people 65+</td>
<td>PNEUM</td>
</tr>
<tr>
<td>Current smoking status</td>
<td>CURSMK</td>
</tr>
<tr>
<td>Obesity</td>
<td>OBESE</td>
</tr>
<tr>
<td>Binge drinking</td>
<td>BINGE</td>
</tr>
<tr>
<td>Ever tested for HIV, excluding tested when donating blood, people 18-64</td>
<td>HIVTEST</td>
</tr>
<tr>
<td>Any activities limited due to physical, mental, or emotional problems</td>
<td>LIMACT</td>
</tr>
</tbody>
</table>
Evaluation
(Mean Square Ratio (MSR) of key outcome measures by state)
Evaluation

(Mean Square Ratio (MSR) by key outcome measure across states)
Conclusions

- For estimates that are influenced by the socioeconomic status of respondents, ITSA seems to reduce the bias due to lack of telephone coverage without increasing the variance of estimates significantly.

- It is expected that the ITSA type weighting will be more effective when applied within weighting cells indexed by categories of household income or education.

- There are other sources of bias for RDD surveys, such as the emerging prevalence of cell-only households, which need to be addressed.
References


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