USE OF DATA ON INTERRUPTIONS IN TELEPHONE SERVICE FOR NONCOVERAGE ADJUSTMENT

M.R. Frankel, T. Ezzati-Rice, R.A. Wright, and K.P. Srinath, Abt Associates Inc. and National Center for Health Statistics
K.P. Srinath, 4800 Montgomery Lane, Bethesda, MD 20814

Key Words: Weighting Adjustment, Nontelephone Households

1. Introduction

Telephone surveys are subject to coverage bias due to noncoverage of nontelephone households. Though the percent of households not having telephone service is small nationally, it can vary substantially by geographic area and by socio-economic factors. For example, it is known that the percentage of households not having telephoneservice is greater among low income households than households in other income groups and therefore may not be adequately represented in a telephone survey. Postsurvey weighting is a method of reducing this bias due to noncoverage of nontelephone households. Keeter (1995) observed that telephone households at any given time also include households that were recently a part of the nontelephone population. These are households with interruption in telephone service. By comparing the characteristics of these households with those without telephones, he showed that it is possible to use the data from households with interruption in telephone service to adjust for noncoverage of nontelephone households.

Brick et. al., (1996) suggested a method of adjusting the survey estimates to reduce the bias due to noncoverage by using the data on interruption in telephone service. During 1997, a household survey using random-digit-dialing (RDD) on health related issues was conducted in the States of Iowa and Washington. In this survey known as the State and Local Area Integrated Telephone Survey (SLAITS), data was also collected on interruption in telephone service during the previous 12 months. In this paper, we apply the method suggested by Brick et.al., to adjust for noncoverage of nontelephone households in Iowa and Washington. We also suggest two other similar methods for adjustment of weights to account for noncoverage. The first method uses the estimated number of persons by telephone status categories from the Current Population Survey (CPS). The second method estimates the probability of response based on the length of interruption in telephone service during the past year. We compare the estimates obtained using the adjusted weights with estimates that do not explicitly adjust for noncoverage.

By comparing the characteristics of households with and without interruption in telephone service and looking at the overall adjusted estimates, we are able generally to conclude that estimates obtained by using adjusted weights using data on interruption in telephone service have a smaller bias than estimates obtained by using poststratification weights without explicit weight adjustment for noncoverage. Also, the increase in the variance due to this adjustment is marginal as seen from the mean squared errors of the unadjusted estimates.

2. Data on Telephone Coverage and Interruption

The telephone coverage in Iowa and Washington is higher than the national average. Table 1 gives the telephone coverage in these two States for various income groups based on the average of 1995 and 1996 CPS data. Table 1 shows that the percentage of individuals without telephone service is larger in lower income groups than the percentage in higher income groups.

Table 2 gives the weighted percentages of individuals with telephones , but with an interruption in telephone service in Iowa and Washington based on data collected from the 1997 SLAITS.

Table 1: Telephone Coverage by Income Groups

Income Group	Percentage of Individuals without Telephone Service	
	Iowa	Washington
<$10,000	7.2	13.9
10,000-15,000	10.1	10.2
15,000-30,000	4.9	4.7
30,000-50,000	1.1	2.7
≥50,000	1.8	1.5
Total	**4.5**	**4.8**

Table 2: Percent Reporting Interruption in Telephone Service (Weighted)

Telephone Status	Iowa	Washington
	%	%
Interruption	4.1	4.0
No Interruption	95.9	96.0
Total	100.0	100.0

3. Comparison of Individuals With and Without Interruption in Telephone Service

Table 3 shows the weighted estimates of health-related characteristics of interest of persons (using the nonresponse-adjusted base sampling weight raked to known population totals for age, sex, race and income categories) separately for individuals with an interruption in telephone service and individuals without an interruption in telephone service for Iowa. As expected, individuals who had experienced an interruption in telephone service have lower incomes than individuals with continuous telephone service. Generally, individuals who have had an interruption in telephone service display a pattern of health service access and use that is consistent with that of low-income households.

Table 3: Estimated Percentage of Persons in Households With and Without Interruption in Telephone Service

Characteristic	Iowa		
	I[1]	NI[2]	Total
Having No Health Insurance	**20.9**	5.8	6.5
Having Any Health Insurance	**78.2**	94.0	93.3
Having Medicare	**7.4**	14.5	14.2
Having Public Insurance	**21.0**	6.3	6.9
State-Sponsored Insurance	**16.3**	0.9	1.6
Medicaid	**16.5**	5.4	5.9
Medical Care Not Afforded	**40.5**	9.1	10.4
Family Income Less than $10,000	**27.2**	8.4	9.2
Family income less than $20,000	**69.4**	23.7	25.6

[1] Individuals from households with interruption in telephone service

[2] Individuals from households without interruption in telephone service

4. Methods of Adjustment

The population of individuals of interest can be partitioned into three strata. The first stratum consists of individuals from telephone households with no telephone interruptions during the past year. The second stratum consists of individuals coming from households with or without telephones at the time of the survey but with interruptions in telephone service during the past year. The third stratum consists of individuals in nontelephone households with no interruptions in telephone service during the past year. That is, the households in the third stratum did not have a telephone during the entire past year. If we are doing a telephone survey of households, we would have a sample of individuals from the first two strata and no sample from the third stratum of individuals.

Let the size of the population of individuals in the three strata be N_1, N_2 and N_3. Let N denote the total population size. $N=N_1+N_2+N_3$. N_1, N_2 and N_3 are unknown. N_2 the number of individuals coming from households with interruption in telephone service can be split into two groups. N_{21} individuals coming from households having a telephone at the time of the survey and N_{22} individuals not having a telephone at the time of the survey. We partition the universe of individuals into four groups as shown below.

Telephone Interruption Status	Telephone Status at the time of the Survey	
	Telephone Households	Nontelephone Households
No Interruption	N_1	N_3
Interruption	N_{21}	N_{22}
Total	N_t	N_{nt}

From the partitioning given above, we see that the population of interest can also be split into the individuals coming from households with a telephone at the time of the survey and individuals coming from households with no telephone at the time of the survey. We denote the population and the sample (in SLAITS) from each of these groups as shown below.

Population: N_1 N_{21} N_{22} N_3
Sample: n_1 n_{21} 0 0

We have samples from the first two groups and no samples from the last two groups. But groups 2 and 3 are similar as both contain households with interruption in telephone service and come from the same stratum. The number of telephone households in the population at the time of the survey is $N_t=N_1+N_{21}$ and the number of nontelephone households is $N_{nt}=N_{22}+N_3$. N_t and N_{nt} are not known. We consider three methods of adjustment and these are described below.

Method 1: Straight Weight Adjustment

In this method, we make the basic assumption that the mean of a characteristic of interest for individuals coming from households with interruption in telephone service is closer to the mean for the nontelephone households. Based on this assumption, we increase the weight attached to individuals from households with interruption in telephone service.

The adjustment to the weight is done in each household income category using 7 income categories for Iowa and 5 income categories for Washington. Let the population control total in the hth income category be N_h. Divide this control into two groups, those coming from households with telephones and those coming from households without telephones. This is done by using 1997 CPS estimate of proportion of persons in telephone households for that income category. Let the estimated control totals be $\hat{N}_{ht}$ and $\hat{N}_{hnt}$. Let the sample number of individuals in the income category having interruption in telephone service be n_{hI} and the number having no interruption be n_{hnI}. Now adjust the nonresponse adjusted base sampling weights of n_{hnI} individuals so that the sum of the weights is equal to $\hat{N}_{ht}(1-\frac{n_{hI}}{n_h})$ and adjust the weights of n_{hI} such that the sum of the weights is $\hat{N}_{hnt}+\hat{N}_{ht}\frac{n_{hI}}{n_h}$.

If w_{hinI} is the nonresponse adjusted base sampling weight for the ith individual coming from a household without interruption in telephone service in the hth poststratum, then the adjusted weight w^*_{hinI} is given by

$$w^*_{hinI} = w_{hinI} \frac{\hat{N}_{ht}(1 - \frac{n_{hI}}{n_h})}{\hat{N}_{htnI}}$$

where $\hat{N}_{htnI} = \sum_{i=1}^{n_{hnI}} w_{hinI}$. A similar adjustment is made to individuals coming from telephone households with interruption in service. That is,

$$w^*_{hiI} = w_{hiI} \frac{\hat{N}_{hnt} + \hat{N}_{ht}(\frac{n_{hI}}{n_h})}{\hat{N}_{hI}}$$

where $\hat{N}_{hIt} = \sum_{i=1}^{n_{hI}} w_{hiI}$.

In this method, the weights attached to individuals coming from households with interruption are substantially increased to account for individuals from nontelephone households with and without interruption in telephone service. All the adjusted weights are raked to the CPS totals for age, sex and race categories.

Method 2: Adjusting the weight using a ratio of estimated totals.

This method is the same as the one proposed by Brick, Waksberg and Keeter (1996). In this method we adjust for individuals in nontelephone households by adjusting the weight for individuals from households with interruption in telephone service. The adjustment is done within each household income category. We describe the method below.

For this method, we again use the partitioning of the universe of individuals into four groups depending on the telephone status of households. From SLAITS, we can only estimate N_1 and N_{21}. Let the estimated number of individuals in households without interruption in telephone service in a stratum be t^*_1. These estimates are obtained using the nonresponse adjusted base sampling weight. Let the estimated number of individuals in households with interruption in telephone service be t^*_2. Let the corresponding estimates from CPS be $\hat{t}_1$ and $\hat{t}_2$ respectively. Brick, Waksberg and Keeter assume that $N_3 = 0$. Let the estimate of N_{22} from CPS be $\hat{t}_4$. Let the nonresponse adjusted base sampling weight for the individuals coming from a household with interruption in telephone service be w_i. The adjusted weight before poststratfication adjustments is given by

$$w^*_i = w_i \left(1 + \frac{\frac{\hat{t}_4}{(\hat{t}_1 + \hat{t}_2)}}{\frac{t^*_2}{(t^*_1 + t^*_2)}}\right).$$

If the two denominators are similar, then we are essentially using t^*_2 which is an estimate of N_{21} to estimate for both $N_{21} + N_{22}$.

After this adjustment to the base sampling weight, the adjusted weights are raked to the known CPS totals for age, race and sex.

Method 3: Politz and Simmons Type of Adjustment

As indicated earlier, the individuals from households with interruption in telephone service can be split into two groups. Those having telephones at the time of the survey and those not having telephones. We have data from the group with interruption and with telephones. This is a sample from stratum 2. This can be used to estimate for the whole stratum. The group with interruption in telephone service (without and with telephone service at the time of the survey) have different probabilities of being selected in the survey. The probability of selection depends on the length of interruption of telephone service during the past year and is between zero and one.

We group the individuals in households with interruption in telephone service by the length of interruption in days during the past year. We use 5 categories for the length of interruption in days. The categories by length of interruption are 8 to 29 days, 30 to 89 days, 90 to 179 days, 180-269 days 270 days and more. We create weights for individuals in each of the five groups as follows.

Interruption in Days	Weight Adjustment
8-29	12/11
30-89	12/9
90-180	12/6
180-270	12/3
270+	12/1

The nonresponse adjusted base weight for individuals with telephone service will be multiplied by the weights shown above. The expected value of the sample mean for telephone households using the adjusted weights is expected to be closer to the population mean of the nontelephone households thus reducing the bias.

After this adjustment, the usual poststratification adjustments are made to the weights through raking using the control totals from the CPS.

5. Coverage Bias and Mean Squared Error

It is not possible to determine the bias in the three adjusted estimates and the usual poststratified estimate to check whether the adjustment for noncoverage reduces the bias in the estimates as compared to estimate without this adjustment. If we assume that the adjusted estimates are unbiased, then the amount of bias in the unadjusted estimates is measured as the difference between the adjusted and the unadjusted estimate. The square of this bias is added to the variance of the unadjusted estimate to compute the mean squared error. The mean squared error is compared with the variance of the adjusted estimates to determine whether the weight adjustment increases the variance substantially. We first give the estimates of some important characteristics using the weights derived by the three methods of adjustment and the standard SLAITS estimate which uses the nonresponse adjusted base sampling weight raked to population totals from the CPS.

Tables 4 and 5 give the combined estimate (both for individuals with and without interruption) for Iowa and Washington. Four estimates are given.

The first estimate is the standard simple poststratification estimate in which the nonresponse adjusted base sampling weight is adjusted such that the sum of the weights agrees with the age, sex, race and income marginal totals. Estimates 2, 3, and 4 use the data on interruption in telephone service. The second estimate uses straight weight adjustment in which the weights of the individuals with interruption in telephone service are adjusted such that the sum of the weights agrees with the estimated total number of individuals in nontelephone households and households with an interruption in telephone service. The sum of the weights for telephone individuals agrees with the estimated number of individuals coming from telephone households without an interruption in telephone service. Estimate 3 is obtained by using the ratio approach similar to Brick, Waksberg, and Keeter for adjusting the weights of individuals with an interruption. Estimate 4 is obtained by using the Politz and Simmons type of adjustment based on the length of interruption in telephone service.

Table 4: SLAITS Estimates by Different Methods Iowa

Characteristic	1	2	3	4
	SPST[1]	SWAD[2]	RATIO[3]	Poli-Sim[4]
No Health Insurance	6.5	**7.2**	**7.1**	6.9
Any Health Insurance	93.3	**92.5**	**92.6**	93.1
Medicare	14.2	**14.5**	**14.5**	14.3
Public Insurance	6.9	**6.7**	**6.7**	7.2
State Sponsored Insurance	1.6	**2.0**	**1.9**	1.5
Medicaid	5.9	**5.6**	**5.6**	5.3
Family Income Less than $10,000 dollars	9.2	**9.6**	**9.6**	9.2

[1] Simple Poststratification
[2] Straight Weight Adjustment
[3] Ratio Method
[4] Politz-Simmons Type Adjustment

Table 5 SLAITS Estimates by Different Methods- Washington

Characteristic	SPST	SWAD	Ratio	Poli-Sim
No Health Insurance	10.1	10.1	10.1	9.8
Any Health Insurance	89.1	88.8	88.7	89.3
Medicare	11.5	11.7	11.7	11.6
Public Insurance	10.3	9.3	9.3	9.4
State-Sponsored Insurance	7.8	8.3	8.1	8.7
Medicaid	8.6	7.5	7.5	7.6
Family Income < 10,000 dollars	13.9	13.8	13.8	13.8

From Tables 4 and 5 we see that the though the differences in the estimates are small, the estimates obtained using adjusted weights generally tend to move more in the direction of the estimates for households with interruption in telephone service. If we assume that households with interruption are more likely to resemble households without telephones, then it is reasonable to assume that the overall adjusted estimates are less biased than those without this adjustment. Tables 6 and 7 give the variance and the mean squared error of the estimates using Method 1 and Method 3 weights and the poststratification weight without adjustment.

Table 6: Variance and Mean Squared Error Iowa

Characteristic	Method I Variance	Method III Variance	MSE PST Est.
No Health Insurance	0.61	0.61	0.99
Any Health Insurance	0.62	0.62	1.14
Medicare	1.12	1.08	1.03
Public Insurance	0.12	0.13	0.15
State Sponsored Insurance	0.70	0.46	0.43
Medicaid	0.17	0.17	0.23

Table 7: Variance and Mean Squared Error Washington

Characteristic	Method I Variance	Method III Variance	MSE PST.EST.
No Health Insurance	1.02	1.07	1.06
Any Health Insurance	1.10	1.13	1.23
Medicare	0.86	0.86	1.08
Public Insurance	0.23	0.25	1.32
State Sponsored Insurance	1.08	1.05	1.31

The variances for Method II are not given as they are very similar to the variances under Method 1.

Conclusions

The results presented in the paper suggest that adjusting the weights of individual respondents from households with interruption in telephone service is useful in reducing the bias due to noncoverage. A further useful study is to look at the characteristics of households with interruption in service and households without telephone service for the entire year to validate the assumptions made in this study.

References

Brick, J., Waksberg, J., and Keeter, S. (1996). Using Data on Interruptions in Telephone Service as Coverage Adjustments, Survey Methodology, Vol.22. Pp. 185-197.

Keeter, S. (1995). Estimating Noncoverage Bias from a Phone Survey. Public Opinion Quarterly, 59, 196-217 .