Evaluation of a Procedure Based on Interruptions in Telephone Service for Reducing Coverage Bias in RDD Surveys

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Introduction

It is well known that telephone surveys are subject to coverage bias because of noncoverage of nontelephone households. Although only around 5% of the households in the U.S. do not have a telephone, rates of telephone coverage show substantial variation by geography, and demographic and socioeconomic factors. In particular, lack of telephone service is more common among households that contain ethnic and racial minorities or that have lower socioeconomic status. There is some evidence to suggest that the percent of households without telephone service is higher in households with children below 3 years than other households.

The National Immunization Survey (NIS) is a random-digit-dialing (RDD) survey of telephone households with children between 19 and 35 months that is used to estimate vaccination coverage rates for 78 Immunization Action Plan (IAP) areas, consisting of the 50 states, the District of Columbia and 27 metropolitan areas. These rates have to be adjusted for noncoverage of nontelephone households. One method of adjustment is a widely-used estimation technique known as simple poststratification which involves adjusting the sampling weights of children with completed interviews such that the sum of the weights agrees with known population control totals by child's age, mother's race/ethnicity and mother's education. This adjustment partially reduces the bias. A drawback of this method is that it assumes that the percentage of children vaccinated within each poststratification cell is the same for telephone and nontelephone households. But, there is evidence to suggest that telephone status is related to vaccination status. Therefore, in the NIS this adjustment is currently done through a method known as modified poststratification which aims to reduce noncoverage bias to a greater degree than is possible with simple poststratification. For a detailed description of the NIS methodology please see Smith et al. (2001) and Zell et al. (2000).

The basic idea in modified poststratification is to split each poststratification cell into two subcells; number of children who are up-to-date and the number who are not up-to-date for 4:3:1:3 vaccination series which is a combination of 4 or more doses of DTP, 3 or more doses of polio virus, 1 dose of measles-containing vaccine (MCV) and 3 doses of Hib. An assumption underlying this method is that the ratio of vaccination coverage rate for 4:3:1:3 series for children in nontelephone households to telephone households in the NIS is the same as the ratio of rates for nontelephone to telephone households in the National Immunization Provider Record Check Study (NIPRCS) in the National Health Interview Survey (NHIS). For a description of NIPRCS, please see Peak and Cadell (1996). Since NHIS/ NIPRCS covers both telephone and nontelephone households, this ratio is known. The unknown coverage rate for nontelephone households in the NIS is estimated by multiplying ratio of 4:3:1:3 vaccination coverage rates in telephone households by the ratio of 4:3:1:3 vaccination coverage rates for children in nontelephone to telephone households in the NHIS/NIPRCS. In this method, 4:3:1:3 up-to-date rate serves as a proxy for up-to-date rates for other vaccines. Further details of the modified poststratification method can be found in Battaglia et al. (1995). Over the last few years, we have been investigating another method of adjusting for noncoverage of nontelephone households in the NIS. This method is based on the data obtained from telephone households in the NIS that had interruptions in their telephone service during the year preceding the survey period. This method is based on the observation by Keeter (1995), that at any given time, the population of telephone households includes households that have had interruptions in telephone service. This means that if the survey had been conducted at some previous point in time, the households that reported interruptions would be considered as part of the population of nontelephone households if they had interruptions at that time. Essentially, we think of the population of households in scope for the survey as consisting of four subpopulations or groups as shown in Table 1. Group T/NI contains persons from households with telephone service (T) at the time of the survey and no interruption in telephone service (NI) during the entire year. Group T/I contains persons from households with telephone service at the time of the survey but interruptions in telephone service (I) during the year. Group NT/I consists of persons from households that did not have telephone service (NT) at the time of the survey but had telephone service at some time during the previous year and finally, Group NT/NI contains persons from households with no telephone service during the entire year. The last group is considered as permanent nontelephone households with no chance of being covered by the NIS. Some of the households in the group NT/I would have had a chance of selection, if the NIS had been conducted at some previous point in time.

Previous studies (Keeter, 1995) have shown that the households with interruptions in telephone service are very similar to nontelephone households at the time of the survey. Therefore, these households may be used to represent the nontelephone households.

The sampling weights of children from households with interruptions in telephone service can be adjusted to account for children in nontelephone households. Details of this adjustment procedure can be found in Frankel et al. (2001). The adjustment based on interruption in telephone service reduces the noncoverage bias especially for those variables that are highly correlated with the presence or absence of telephone service.

This adjustment may lead to a greater variability in the weights determined before adjustment. This increased variability in weights may lead to an increase in the standard errors of the estimates so as to offset the decrease in bias. Therefore, it is important to look at the mean squared error of the estimates at the state level and compare it with the mean squared error of the simple poststratification method which does not make an explicit adjustment for noncoverage of nontelephone households. In this paper, we examine the bias and mean squared error of the interruption estimates at the state level using sampling weights that are adjusted for children in households with interruptions in telephone service.

There is no direct way of assessing the decrease in bias of the interruption estimate as there are no strictly unbiased estimates of vaccination coverage rates available in the NIS because of noncoverage of nontelephone households. Therefore, it is not possible to compute the mean squared error of the estimate based on interruption in telephone service. We have to use the results of surveys that cover both telephone and nontelephone households to demonstrate the usefulness of the interruption method. We looked at the Current Population Survey (CPS) and the NHIS to evaluate the efficiency of the interruption method. The CPS and the NHIS cover both telephone and nontelephone households. Therefore, from these surveys we have estimates that are free of bias due to noncoverage of nontelephone households. The NHIS explicitly collects data on interruption in telephone service and is an ideal candidate to evaluate the interruption method. The CPS does not collect this information. In the CPS, the selected households stay in the sample for the first four months, then are out of the sample for 8 months and they are back in the sample for the next four months. Therefore, on the basis of the telephone status at the first month and the fifth month of their stay in the sample, it is possible to classify households into proxy interruption and no interruption groups as described in detail later. To evaluate the bias and the mean squared error, we used the interruption method to produce estimates of selected characteristics that are correlated with presence or absence of the telephone based only on telephone households and also the simple poststratification estimates again based on telephone households.

In this paper, we describe the procedure for producing the interruption estimates from both the CPS and the NHIS. The results from the CPS are to demonstrate the decrease in bias in the estimates based on the interruption adjustment as compared to the bias in simple poststratification estimates. The results from the NHIS show the mean squared errors both for the interruption method and the simple poststratfication method.

Estimates from the CPS

Groups NT/I and NT/NI are nontelephone households at the time of the survey. If a moderate proportion of this combined group belongs to group NT/I, which is considered to be similar to group T/I (since both had interruptions in telephone service), it is a reasonable strategy to use the telephone interruption group (T/I) to adjust for the noncoverage of nontelephone groups NT/I and NT/NI.

To examine whether the assumptions stated above are valid, we took 18 monthly samples from 1996, 1997 and first half of 1998 from the CPS and looked at the phone status of persons in the sample in their first and fifth month in the CPS and persons who had a telephone at the fifth month were considered as coming from telephone households. Out of this group, those that did not have a telephone at the first month were considered to be the interruption group, Similarly, those that did not have a telephone at the fifth month belong to the nontelephone group and out of this group, those that did have a telephone in the first month are considered to be the nontelephone interruption group. We computed the estimates of unemployment rates for these groups. We found that generally 40 to 60% of the of the nontelephone group is the interruption group. We also found that generally, the estimates for the NT/NI group was very different from the other three groups, it was closer to the estimates for the two interruption groups than the estimates for the telephone without interruption group T/NI. Therefore, it is reasonable to use the telephone with interruption group to adjust for noncoverage of households in the NT/NI group. Table 2 shows the estimates for the different groups for selected states.

Table 3 shows for selected states the overall estimate based on both telephone and nontelephone households, the estimates based only on telephone households (simple poststratification estimates) and the estimate that uses the interruption adjustment to adjust for nontelephone households. As indicated earlier, it is the usual practice in RDD surveys to adjust the weights to agree with the known poststratification totals by age, race and sex. Therefore, we adjusted both the telephone only estimate weight and the interruption based weight such that the sum of the weights agree with known control totals by age, race and sex. These totals were obtained by taking the full CPS data and aggregating the CPS weights by age, race and sex.

We also computed the ratio of estimated absolute bias of the simple poststratification estimate to that of the interruption estimate. The estimated absolute bias of the simple poststratification estimate is the absolute difference between this estimate and the overall estimate. The estimated bias of the interruption is obtained similarly. These ratios of the absolute bias are shown in Table 3. If the ratio of the absolute bias is bigger than one, then the interruption estimate is closer to the overall estimate. We found that out of the 52 estimates (U.S., 50 states and the

District of Columbia) the interruption estimate is closer to the overall estimate than the simple poststratification estimates in 36 cases. 16 estimates show a ratio of less than one implying a larger deviation of the interruption estimate than the simple poststratification estimate from the overall estimate

Estimates from the NHIS

We examined the estimates of four health characteristics for all persons using the 1997-99 NHIS data and the NHIS weights for the nine largest states in terms of the NHIS sample size. The four health characteristics for which estimates were obtained are No Health Insurance, Self-Reported Fair/Poor Health Status, Medicaid Participation, No Health Care Due to Cost. Table 4 presents the estimates of the four health characteristics for the four groups that include telephone and nontelephone households for five states out of the nine selected. Table 5 includes a set of sub-tables, one for each of the selected states. In each sub-table, estimates based on the overall sample which includes both the telephone and nontelephone households are given. The estimates are percentages of persons having no insurance, having Medicaid etc. For example, in California, 19.16% of persons have no health insurance. The overall estimates are considered to be unbiased for the population values which are being estimated.

Simple poststratification estimates (using age by sex by race category) based only on telephone households and the estimates which adjust the weights of persons in telephone households with interruption to account for nontelephone households are also given. Estimates of bias are computed by taking the difference of the simple poststratification estimate and the interruption estimate from the overall estimate. Standard errors were calculated using SUDAAN (version 8.0). The ratios of the mean squared error of the simple poststratification estimate to the interruption estimate are shown in Table 4. If this ratio is greater than one, the interruption has a smaller mean squared error than the simple poststratification estimate. Table 4 clearly demonstrates that the estimates for the telephone interruption group are closer to the two nontelephone groups than the estimates for the telephone without interruption group especially for the variable health insurance

From Table 5, we see that generally the interruption estimates are closer to the overall estimates than the simple poststratification estimates. The ratio of the mean squared error of the simple poststratification estimate to the interruption estimate is generally larger than one. We examined 36 sets of estimates. The interruption estimate had a lower mean squared error than the simple poststratification estimate in 83% of the cases. The slight increase in the standard error of the interruption estimate does not offset the reduction in bias in the interruption estimate thus giving a lower mean squared error than the simple poststratficiation estimate.

The conclusion of this analysis is that the adjustment for noncoverage of nontelephone households using the interruption in telephone service methodology performs well at the state level compared to simple poststratification.. In this study, we have not compared the modified poststratification method which is currently in use for the NIS.

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Table 1: Definition of the Telephone and Interruption Groups at the Time of the Survey

Telephone Status at the Time of the Survey	Interruption Status		Total
	Interruption	No Interruption	
Telephone	T/I	T/NI	T
No Telephone	NT/I	NT/NI	NT
Total	I	NI	

Table 2: Percent Unemployed and Sample Sizes for Selected States by Telephone and Interruption Groups CPS 1996-1998

State	Telephone Without Interruption (T/NI)	Telephone with Interruption (T/I)	NonTelephone With Interruption (NT/I)	Nontelephone Without Interruption (NT/NI)
U.S.	3.54 (96,273)	**8.06** (1,493)	**6.56** (2,250)	**11.1** (1,210)
AL	**3.63 (1337)**	**12.80 (22)**	**10.45 (53)**	**32.26 (21)**
CA	**4.39 (7,130)**	**7.27 (125)**	**4.11 (212)**	**7.32 (56)**
FL	**3.20 (3,798)**	**5.11 (80)**	**8.40 (134)**	**11.49 (50)**
GA	**2.92 (1,678)**	**10.85 (59)**	**5.41 (37)**	**15.55 (49)**
LA	**3.41 (1,233)**	**7.96 (35)**	**20.69 (22)**	**17.15 (32)**
MS	**3.98 (1,080)**	**12.91 (33)**	**7.20 (38)**	**20.44 (40)**
NM	**4.07 (1,171)**	**8.51 (30)**	**13.05 (34)**	**20.90 (37)**
NY	**4.78 (5,810)**	**12.58 (104)**	**8.86 (135)**	**17.76 (35)**
WA	**3.41 (1,283)**	**6.30 (14)**	**4.97 (17)**	**28.96 (16)**
WV	**4.52 (1,248)**	**17.85 (17)**	**4.90 (19)**	**40.17 (19)**

Table 3: Overall, Telephone Only and Interruption Based Estimates of Unemployment Rates With and Without Poststratification
CPS 1996-1998

State	Overall Estimate	No Poststratification		With Poststratification		Ratio of Absolute Bias
		Telephone Only Estimate	Interruption Estimate	Telephone Only Estimate	Interruption Estimate	
U.S.	**3.78**	**3.61**	**3.77**	**3.45**	**3.61**	**1.94**
AL	**4.48**	**3.78**	**4.28**	**3.57**	**4.09**	**2.33**
CA	**4.45**	**4.44**	**4.54**	**4.24**	**4.35**	**2.10**
FL	**3.52**	**3.24**	**3.33**	**3.18**	**3.29**	**1.48**
GA	**3.64**	**3.20**	**3.60**	**3.16**	**3.56**	**6.00**
LA	**4.18**	**3.53**	**3.72**	**3.67**	**3.88**	**1.70**
MS	**4.93**	**4.26**	**4.83**	**4.34**	**4.92**	**59.00**
NM	**4.93**	**4.19**	**4.44**	**4.10**	**4.39**	**1.54**
NY	**5.09**	**4.93**	**5.14**	**4.80**	**5.01**	**3.62**
WA	**3.75**	**3.44**	**3.51**	**3.08**	**3.17**	**1.16**
WV	**5.23**	**4.71**	**5.09**	**4.57**	**4.98**	**2.64**

Table 4: Percentages of Adults (18 years and older) with Selected Characteristics by Telephone and Interruption Status in Selected States NHIS 1997-1999

State	No Phone With Interruption (NT/I)	No Phone No Interruption (NT/I)	Phone With Interruption (T/I)	Phone and No Interruption (T/NI)
California				
No Insurance	**37.6**	**38.65**	**31.72**	**18.27**
Fair/Poor health	**10.97**	**14.62**	**10.23**	**8.19**
Medicaid	**38.24**	**35.91**	**31.21**	**11.24**
No Care-Cost	**8.35**	**8.92**	**10.25**	**3.78**
Texas				
No Insurance	**55.16**	**52.09**	**39.08**	**20.87**
Fair/Poor health	**12.73**	**13.87**	**9.89**	**8.58**
Medicaid	**16.66**	**21.52**	**19.14**	**6.11**
No Care-Cost	**8.17**	**10.42**	**10.82**	**4.19**
Florida				
No Insurance	**51.9**	**51.68**	**27.61**	**18.63**
Fair/Poor health	**13.22**	**14.26**	**12.78**	**9.55**
Medicaid	**22.38**	**16.39**	**20.68**	**5.92**
No Care-Cost	**17.15**	**14.20**	**9.90**	**5.18**
New York				
No Insurance	**24.02**	**29.08**	**24.76**	**13.30**
Fair/Poor Health	**10.33**	**22.00**	**12.63**	**8.32**
Medicaid	**50.00**	**48.78**	**29.51**	**10.51**
No Care-Cost	**4.76**	**8.63**	**10.24**	**3.38**

Table 5: Comparison of Estimates and Mean Squared Errors (MSE) based on simple Poststratification and Interruption Methods

California

Health Characteristic	Overall Estimate	Simple Poststr. Estimate (SP)	Interruption Estimate (INTP)	MSE SP Est.	MSE INTP Est.	MSE Ratio SP/INT
No Insurance	19.16	18.75	19.0	0.389	0.2657	1.46
Fair/Poor Health	8.37	8.18	8.3	0.089	0.0578	1.54
Medicaid	12.45	11.76	12.27	0.661	0.244	2.71
No Care-Cost	4.06	3.92	4.11	0.0421	0.0281	1.50

Texas

Health Characteristic	Overall Estimate	Simple Poststr. Estimate (SP)	Interruption Estimate (INTP)	MSE SP Est.	MSE INTP Est.	MSE Ratio SP/INT
No Insurance	23.45	22.06	22.65	2.4946	1.3124	1.90
Fair/Poor Health	8.91	8.56	8.73	0.2186	0.1413	1.55
Medicaid	7.37	6.78	7.31	0.5882	0.3285	1.79
No Care-Cost	4.74	4.45	4.82	0.1202	0.0505	2.38

Florida

Health Characteristic	Overall Estimate	Simple Poststr. Estimate (SP)	Interruption Estimate (INTP)	MSE SP Est.	MSE INTP Est.	MSE Ratio SP/INT
No Insurance	19.61	18.48	18.73	1.6738	1.1713	1.43
Fair/Poor Health	9.77	9.51	9.78	0.1901	0.1445	1.31
Medicaid	6.66	6.28	6.79	0.2888	0.2285	1.26
No Care-Cost	5.66	5.27	5.46	0.225	0.1129	1.99

New York

Health Characteristic	Overall Estimate	Simple Poststr. Estimate (SP)	Interruption Estimate (INTP)	MSE SP Est.	MSE INTP Est.	MSE Ratio SP/INT
No Insurance	13.78	13.59	13.75	0.3277	0.3034	1.08
air/Poor Health	8.61	8.38	8.52	0.149	0.1105	1.35
Medicaid	11.67	10.95	11.31	0.8665	0.5017	1.72
No Care-Cost	3.57	3.49	3.64	0.0905	0.089	1.01