

## An Evaluation of Methods to Compensate for Noncoverage of Nontelephone Households using Information on Interruptions in Telephone Service and Presence of Wireless Phones

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### Abstract<sup>1</sup>

For legal and operational reasons, wireless phone numbers are usually excluded from RDD surveys. Wireless-only households are rapidly growing and about 6-10% of the U.S. households are wireless-only. Estimates from RDD surveys are subject to potential bias due to noncoverage of households without landline telephones. We use combined data from the 2003-2004 NHIS to compare characteristics of adults living in phoneless households with those living in wireless-only households or households with interruptions in telephone service. We selected a random sample of telephone households and evaluated ratio- and propensity-based weighting methods to compensate for noncoverage of phoneless and wireless-only households using information on interruptions in landline telephone service and presence of wireless telephones. To assess bias, resulting estimates are compared with the annual NHIS estimates.

**Keywords:** Weighting methods, propensity score methods, ratio adjustments, RDD telephone survey

### 1. Introduction:

Random-digit-dialing (RDD) telephone surveys are the quickest way to collect data and investigate emerging public health issues. Estimates from RDD surveys are subject to potential bias due to noncoverage of households without landline telephones (i.e., nontelephone households) that include both households without any telephones (phoneless) and households with access to wireless telephones only (wireless-only). For legal and operational reasons, wireless telephone numbers are usually excluded from the RDD surveys. Access to wireless telephones is rapidly growing and about 6-10% of the U.S. households are currently wireless-only. Blumberg *et al.* (2005, 2006a, 2006b) used data from the National Health Interview Survey (NHIS), which covers both telephone and nontelephone US households to show that trends in wireless substitution among adults increased from 2.8% in 2003 to 7.8% in 2005 while prevalence of phoneless households remained unchanged (1.5-1.7%). Blumberg *et al.* (2006a, 2006b) also showed that the prevalence of wireless substitution is higher among certain demographic subgroups including men, adults

aged 24 years or younger, living in poverty, renting their home, living alone or living with unrelated roommates. In comparison to adults with wireless-only telephone service, adults without any telephone service had lower education and were more likely to be older, unemployed, and poor.

Rates of landline telephone coverage show substantial variation by geography, demography, and socioeconomic status of household members. Therefore, valid and practical methods are needed to adjust survey estimates for the potential bias in RDD survey estimates due to this disparity and noncoverage of phoneless and wireless-only households.

Keeter (1995), Brick *et al.* (1996), Frankel *et al.* (2003), and Srinath *et al.* (2002) showed that the socioeconomic characteristics of persons who live in households with interruptions of one week or more in landline telephone service within the past 12 months are similar to those who live in nontelephone households. This is because if the survey had been conducted at some point in time, when the household had interruptions, it would have been considered as part of the population of nontelephone households (with or without access to a wireless telephone). Therefore, persons living in households with interruption in landline telephone service can be used to represent persons living in nontelephone households in RDD surveys. The goal of our research is to investigate whether separate methods are needed to adjust for noncoverage of wireless-only and phoneless households using information on interruptions in telephone services and access to wireless telephones reported by the respondents.

### 2. Data

The target population for the NHIS is the US civilian non-institutionalized resident population (with or without access to telephones) and data are collected through in-person interviews. In 2003, a question about access to wireless telephones was added to the NHIS. We used two years of combined data from the 2003-2004 NHIS to model and compare characteristics of adults living in phoneless households, wireless-only households, or in households with interruptions in landline telephone (LT) service.

Depending on access to landline telephones, wireless telephones, and interruptions in LT service, the

<sup>1</sup> "The findings and conclusions in this paper are those of the author(s) and do not necessarily represent the views of the National Center for Health Statistics, Centers for Disease Control and Prevention."

population of the households in scope for the RDD surveys can be considered as consisting of six groups as follows:

- 1) Group LTNI containing persons from households with only LT service and no interruption in landline telephone service (NI).
- 2) Group LTWNI containing persons from households with LT and wireless telephone service at the time of the survey and no interruption in landline telephone service (NI).
- 3) Group LTI containing persons from households with only LT service at the time of the survey and had interruptions in LT service (I) of one week or more during previous 12 months.
- 4) Group LTWI containing persons from households with both LT and wireless telephones service at the time of the survey and had interruptions in LT service (I) of one week or more during the previous 12 months.
- 5) Group WP containing persons from households that did not have any LT service during the previous year and had at least one household member with access to a wireless telephone during that time.
- 6) Group NP containing persons from households with no LT or wireless telephone service in the household during the previous year (i.e. phoneless households).

The following table summarizes the six groups under consideration in terms of access to landline telephone, interruption in landline service and wireless telephone status.

Telephone Groups	Landline Telephone (LT)		Wireless Telephone (WP)
	No Interruption (NI)	Interruption (I)	
1. LTNI	✓	-	-
2. LTWNI	✓	-	✓
3. LTI	-	✓	-
4. LTWI	-	✓	✓
5. WP	-	-	✓
6. NP	-	-	-

Households in the first two groups are considered as permanent or continuous telephone groups with no interruptions (NI) and the last two groups are considered as permanent nontelephone households with no chance of being covered by RDD surveys. Inclusion of the middle two groups in RDD surveys depends on the time when these households were called. Table 1 shows that 91.6% of the US adults live in LT households, 1.7% in households with interruptions in telephone service (~47% of interrupted households had access to wireless telephones), 4% live in WP only households, and 2.7% live in NP households.

### 3. Methods

Generally, to reduce bias in survey estimates, sampling weights are adjusted for nonresponse and noncoverage. To compare alternate methods of weight

adjustments, we selected the sample of adults aged 18 years and older living in telephone households from the 2004 NHIS and evaluated the ratio- and propensity-based weighting methods for noncoverage (Davis and Khare, 2005). To assess bias in the resulting estimates, mean-squared errors (MSE= Bias<sup>2</sup> + SE<sup>2</sup>) are computed with respect to the national estimates from the 2004 NHIS among adults aged 18 years or older.

First, we used a simple poststratification procedure (SP) to adjust the nonresponse adjusted basic weights (WTIA) in the 2004 NHIS telephone sample for noncoverage by demographic status of the respondents. The new sample weight  $W_i^{SP,ps}$  for unit  $i$  in the poststratification cell,  $ps$ , is define as

$$W_i^{SP,ps} = \frac{N_{LTNI,ps} + N_{LTWNI,ps} + N_{LTI,ps} + N_{LTWI,ps} + N_{NP,ps} + N_{WP,ps}}{\sum_{i \in LTNI,ps} W_i^B + \sum_{i \in LTWNI,ps} W_i^B + \sum_{i \in LTI,ps} W_i^B + \sum_{i \in LTWI,ps} W_i^B},$$

where  $W_i^B$  is the WTIA for unit  $i$  in the telephone subgroups 1-4 and  $Ns$  are the respective population control totals for poststratification cells within subgroups 1-6;  $Ns$  can be estimated by multiplying the total US adult population with proportions of the population in those subgroups from external sources(e.g., the NHIS).

Two alternate weight adjustment methods, M1 and M2, used a direct ratio-adjustment procedure using information on interruption in landline telephone services and access to wireless telephones. These methods are similar to the interruption method used in the National Immunization Survey to compensate for the noncoverage of nontelephone households (Frankel *et al.*, 2003; Smith *et al.*, 2005). In method M1, persons in households without interruptions (NI=LTNI+LTWNI) and with interruptions (I=LTI+LTWI) are separately poststratified to the (LTNI + LTWNI) and the [(LTI+LTWI) + (NP+WP)] population control totals within demographic weighting cells, respectively. Thus, the new noncoverage adjusted sample weight M1 for the unit  $i$  in the NI and I groups are

$$W_i^{M1,NI} = W_i^B * \frac{N_{LTNI,ps} + N_{LTWNI,ps}}{\sum_{i \in LTNI,ps} W_i^B + \sum_{i \in LTWNI,ps} W_i^B},$$

$$W_i^{M1,I} = W_i^B * \frac{(N_{LTI,ps} + N_{LTWI,ps}) + (N_{NP,ps} + N_{WP,ps})}{\sum_{i \in LTI,ps} W_i^B + \sum_{i \in LTWI,ps} W_i^B},$$

respectively.

Method M2 assumed that the characteristics of adults living in LTWI households are similar to those who do not have access to landline telephones but have wireless telephones (WP). Therefore, weights of the adults in the LTWI group are separately adjusted to represent the wireless-only adults using the (WP + LTWI) estimated control totals within weighting cells based on

characteristics associated with the wireless-only status. Weights of adults in the LTI group are separately adjusted to represent the phoneless households using the (NP + LTI) estimated control totals within weighting cells based on characteristics associated with the phoneless status. Thus, the new sample weights M2 for unit  $i$  in the NI, the LTI and the LTWI groups are

$$W_i^{M2,NI} = W_i^B * \frac{N_{LTI,ps} + N_{LTWNI,ps}}{\sum_{i \in LTI,ps} W_i^B + \sum_{i \in LTWNI,ps} W_i^B} = W_i^{M1,NI}$$

$$W_i^{M2,LTI} = W_i^B * \frac{N_{LTI,ps} + N_{NP,ps}}{\sum_{i \in LTI,ps} W_i^B}, \text{ and}$$

$$W_i^{M2,LTWI} = W_i^B * \frac{N_{LTWI,ps} + N_{WP,ps}}{\sum_{i \in LTWI,ps} W_i^B}, \text{ respectively.}$$

An alternative approach to the direct ratio-adjustment and the weighting class methods is to use logistic regression to model response propensities for nontelephone status and use the predicted propensities to adjust sampling weights for noncoverage (Battaglia *et al.*, 1995; Davis and Khare, 2005). In the method M3, we applied a slightly different procedure used by Davis and Khare (2005) and used data from the 2003 and 2004 NHIS to develop separate logistic regression models of response propensities for wireless-only and phoneless households among households with interruptions in landline telephone service (LTI or LTWI). Beta coefficients from the final stepwise logistic regression models were applied to the 2004 NHIS telephone sample to predict the propensity of WP or NP status among respective LTWI and LTI groups. Next, WTIA weights of the adults in the 2004 telephone sample are adjusted by the inverse of the predicted propensity to compensate for the noncoverage; WTIA weights of the adults in the permanent landline telephone group (NI) remained the same.

Finally, a poststratification step adjusted the total weighted cell counts from methods M1--M3 to the total US population within the basic demographic cells. These final poststratified weights are then used to compute the new noncoverage adjusted estimates.

To evaluate the four adjustment methods, weighted estimates of selected health and socio-demographic characteristics are compared. We used self-reported health status, access to private insurance, access to health insurance, and proportion of US population living in poverty to assess bias by taking the difference between the 2004 NHIS estimates and the estimates using the SP and M1--M3 weights. To account for the complex sample design of the NHIS, SUDAAN (Shah *et al.*, 1999) was used to compute standard errors. Differences in and ratios of estimated MSEs are used to compare methods.

## 4. Results

### 4.1. Characteristics of WP and NP groups

Table 1 shows that characteristics of adults with wireless-only telephones and adults living in phoneless households are similar to those reported by Blumberg *et al.* (2006a). Having access to wireless-only telephone service appears higher among adults aged 18-34, males, Hispanics, college graduates, those living alone or with a partner or roommate, those renting homes, those living in households at <200% of poverty level, and with family income <\$40,000. This table also shows that living in phoneless households is higher among young adults, males, Hispanics, those with education of less than high school, those living alone, those renting homes, and those living in households at 100% of poverty levels, or with income <\$10,000. These differences are not tested for statistical significance.

### 4.2. Comparison of WP, NP, LTI, and LTWI groups

Table 2 shows the distribution of adults living in six types of telephone or nontelephone households. The distribution of family income, poverty status, and education status among WP group shows more similarity to the LTWI group than to the NP or LTI groups. The family income distribution also shows that more than 40% of adults in the WP and LTWI groups have income between \$20,000-\$60,000 whereas only 20-30% of adults in the NP and LTI groups have this income; ~ 30% of adults in the NP and LTI groups have income <\$20,000. Characteristics of the NP group show more similarity to the LTI group than to the LTWI or WP groups. These differences are not tested for statistical significance.

### 4.3. Results of propensity model

A subset of the variables listed in Tables 1 and 2 with large percentages among the WP and NP groups are selected to develop the propensity models. The first column of Table 3 lists the set of covariates selected from the stepwise logistic regression models to predict propensity scores for the WP and NP status; estimates of Odds Ratios for the covariates are shown in columns 2 and 3 of the table. In method M2, only covariates with **bolded** Odds Ratios in columns 2 and 3 are used to create weighting class adjustment cells to directly adjust the WTIA weights for noncoverage of adults in the WP and NP groups. In method M3, all applicable socio-demographic covariates listed in the first column are used to separately obtain predicted propensities from the WP and NP models. The inverse of the predicted propensities are used to adjust the WTIA weights for the adults in the LTWI and LTI groups for noncoverage of WP and NP groups, respectively.

### 4.4. Comparison adjustment factors and weighted estimates:

Table 4 shows the distribution of the adjustment factors from the four methods. All four methods show a similar distribution except for higher maximum values and Coefficients of Variations (CV) from methods M1

and M2 due to separate ratio-adjustments for the WP and the NP groups. Ratios of other statistics from method M2 to the other three methods show that the distribution of adjustment factors from methods M2 and M1 are similar; means and medians of the adjustment factors are almost the same across the four methods.

Table 5 presents a comparison of the weighted estimates of prevalence (EST), standard errors (SE) and difference in MSE using 2004 NHIS estimates as true population estimates among adults aged 18-34 years. Table 5 shows that within this age group (which is correlated to wireless-only status) differences in MSEs are the smallest for self-reported health status and poverty status <400% using method M2. Poverty status is correlated to both WP and NP status. Although weighted estimates from the M1 and M2 methods are very close, ratios of MSE (M2/M1) in Table 6 are slightly smaller for poverty status and health status using the M2 method among young adults aged 18-34 years. All MSE ratios for comparing method M2 to M3 are less than 1.0 (range: 0.141 - 0.745); smaller MSE ratios suggest higher reduction in bias using method M2.

## 5. Conclusion

Our analysis shows that adults with access to wireless-only telephones, living in households with interruption in landline telephone service, or living in phoneless households have different socio-demographic characteristics. Adjustments based on interruption in landline telephone service generally reduce the noncoverage bias, especially for those variables that are highly correlated with the presence or absence of landline telephone service.

Methods M1 and M2 appear to perform better than methods SP or M3 and method M2 performed slightly better than method M1. All ratios of MSE (M2/M3) are <1.0 (Table 6) suggesting greater reduction in bias with method M2. However, ratios of MSE (M2/M1) show minimal affect of separate adjustments for wireless-only households on the interruption based estimates (with ratio ~1.0) from method M1.

With increasing trends in prevalence of wireless-only households, using separate adjustments for wireless-only and phoneless household may further reduce bias in population estimates that are correlated to characteristics of wireless-only households. However, to evaluate additional reduction in bias and to adjust for the noncoverage of WP households in RDD surveys, it will be advantageous to add one or more questions on access to wireless telephones.

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**Table 1: Prevalence of telephone coverage among US adults (age ≥18 years) by selected characteristics, 2003-2004 National Health Interview Survey**

Characteristics	Sample Size	Only Landline Telephone Access		Wireless and Landline Telephone Access		Only Wireless Telephone Access WP (%)	Phoneless Household NP (%)
		LTNI (%)	LTI (%)	LTWNI (%)	LTWI (%)		
<b>Total</b>	134286	46.5	0.9	45.1	0.8	4.0	2.7
<b>Age group</b>							
18-34 years	41871	40.0	1.6	44.8	1.3	8.2	4.2
35-54	53880	42.1	0.8	51.1	0.7	2.9	2.4
55+	38535	59.4	0.5	37.2	0.3	1.1	1.5
<b>Gender</b>							
Male	63315	44.9	0.9	45.7	0.8	4.7	3.0
Female	70971	48.0	1.0	44.5	0.8	3.4	2.4
<b>Race/ethnicity</b>							
Hispanic	27742	52.8	1.7	34.9	1.0	5.1	4.6
Non-Hispanic White*	83611	44.7	0.7	48.1	0.7	3.8	2.0
Non-Hispanic Black	22933	49.9	1.5	39.3	1.0	4.3	4.0
<b>House tenure</b>							
Owned	90503	43.8	0.5	52.1	0.6	2.0	1.0
Rented	37834	50.2	2.1	30.3	1.2	9.9	6.4
<b>Household size</b>							
1	19711	59.4	0.9	26.4	0.7	7.6	5.0
2	43178	48.3	0.7	44.3	0.7	3.9	2.1
3	25621	41.6	0.9	50.7	0.7	3.7	2.4
<b>Household Structure</b>							
Living Alone	19711	59.4	0.9	26.4	0.7	7.6	5.0
Living w/Roommate	1923	26.8	1.2	44.0	3.2	18.0	6.9
<b>Poverty Status</b>							
<100%	11204	57.1	3.6	22.0	1.2	7.5	8.6
100-199%	18210	55.5	1.7	31.2	1.6	6.3	3.7
200-399%	28243	43.3	0.8	48.7	0.9	4.8	1.6
400%+	33568	28.1	0.2	67.9	0.6	2.8	0.5
<b>Family Income</b>							
<\$10,000	5930	59.4	3.1	18.7	0.8	7.8	10.3
10,000- <\$20,000	10280	60.9	2.4	22.4	1.1	7.5	5.6
20,000- <\$40,000	21729	51.2	1.4	37.0	1.3	6.5	2.7
\$40,000- <\$60,000	16620	40.0	0.8	52.3	1.0	4.9	1.1
<b>Marital status</b>							
Married	77311	44.2	0.6	50.8	0.6	2.3	1.5
Widowed, Divorced, Separated	22220	58.7	1.2	31.9	0.8	4.2	3.2
Never married	25718	43.6	1.3	42.0	1.2	7.6	4.3
Living with Partner	7664	41.0	2.2	40.0	1.3	9.7	5.8
<b>Education</b>							
≤ High School	26007	59.7	2.2	27.2	0.8	4.1	5.9
High School/ GED	38914	50.1	1.0	41.3	0.8	4.1	2.7
Some College/ College	54547	38.7	0.6	54.0	0.9	4.5	1.4
Graduate School	9821	35.7	0.2	61.0	0.5	2.1	0.5

**Table 2: Percent distribution of US adults (≥18 years) by telephone status, 2003-2004 National Health Interview Survey**

Characteristics	Sample Size	Only Landline Telephone Access		Wireless and Landline Telephone Access		Only Wireless Telephone Access	Phoneless Household
		LTNI (%)	LTI (%)	LTWNI (%)	LTWI (%)	WP (%)	NP (%)
<b>Total</b>	134286	46.5	0.9	45.1	0.8	4.0	2.7
<b>Age group</b>							
18-34 years	41871	26.9	51.2	31.1	51.0	63.7	48.8
35-54	53880	35.7	33.8	44.7	36.2	28.2	35.1
55+	38535	37.3	15.0	24.2	12.8	8.1	16.1
<b>Gender</b>							
Male	63315	46.4	45.6	48.8	48.9	55.9	53.9
Female	70971	53.6	54.4	51.2	51.1	44.1	46.1
<b>Race/ethnicity</b>							
Hispanic	27742	14.1	21.9	9.6	15.6	15.6	21.4
Non-Hispanic White*	83611	69.1	53.3	76.6	64.3	67.6	54.8
Non-Hispanic Black	22933	16.9	24.8	13.8	20.1	16.8	23.8
<b>House tenure</b>							
Owned/buying	90503	66.0	36.7	81.1	55.4	34.3	27.2
Rented	37834	27.4	56.9	17.1	39.1	62.1	60.5
<b>Household size</b>							
1	19711	19.6	15.1	9.0	14.1	28.7	29.0
2	43178	35.1	25.7	33.2	28.3	32.4	27.0
3	25621	17.1	17.1	21.5	17.3	17.7	17.1
<b>Household Structure</b>							
Living Alone	19711	19.6	15.1	9.0	14.1	28.7	29.0
Living w/Roommate	1923	0.9	2.0	1.5	6.5	7.0	4.0
<b>Poverty Status</b>							
<100%	11204	8.8	27.3	3.5	11.3	13.3	22.9
100-199%	18210	14.7	21.9	8.6	25.1	19.4	17.0
200-399%	28243	19.9	17.9	23.1	23.6	25.4	12.6
400%+	33568	16.7	5.1	41.7	22.6	18.9	4.8
<b>Family Income</b>							
<\$10,000	5930	5.3	13.5	1.7	4.3	7.9	15.8
10,000-<\$20,000	10280	9.1	17.6	3.4	10.1	13.0	14.6
20,000-<\$40,000	21729	16.9	22.8	12.6	24.9	24.9	15.5
\$40,000-<\$60,000	16620	10.7	10.3	14.4	15.9	15.0	5.1
<b>Marital status</b>							
Married	77311	55.3	38.9	65.5	44.7	32.9	32.7
Widowed, Divorced, Separated	22220	20.3	21.0	11.4	16.5	16.8	19.4
Never married	25718	17.9	26.5	17.9	29.6	36.3	30.7
Living with Partner	7664	4.9	13.1	4.9	8.9	13.4	12.1
<b>Education</b>							
≤ High School	26007	20.5	37.5	9.6	16.5	16.3	35.0
High School/ GED	38914	31.5	30.4	26.8	29.8	29.7	30.0
Some College/ College	54547	35.8	27.2	51.6	47.8	48.2	21.8
Graduate School	9821	6.2	1.5	11.0	4.8	4.3	1.5

**Table 3: Significant covariates and estimates of Odds Ratios from stepwise logistic regression models for predicting response propensities separately for wireless-only or phoneless status\* among adults (≥18 years) with interruption in landline telephone service with or without access to wireless phones, 2003-2004 National Health Interview Survey.**

Covariates used in the final propensity model*	Model WP <sup>#</sup>	Model NP <sup>#</sup>
	vs LTWI	vs LTI
	Odds Ratios	Odds Ratios
AGEGR4R (1) 18-34 vs (3) 55+	<b>1.893</b>	-
AGEGR4R (2) 35-54 vs (3) 55+	<b>1.311</b>	-
SEX (1) Male vs (2) Female	1.198	<b>1.336</b>
HRACER12 (1) Hispanic vs (3) NH-Black	<b>1.547</b>	-
HRACER12 (2) NH-White/Other vs (3) NH-Black	<b>1.708</b>	-
R_MARITL 1-3 Married vs 7-8,other not married/partner	-	0.891
R_MARITL 4-6 W/D/S vs 7-8,other not married/partner	-	0.735
EDUC_C (0+1) LE High School vs (3+4) Some college/Grad School	1.495	<b>1.496</b>
EDUC_C (2) HS/GED vs (3+4) Some college/Grad School	1.241	<b>1.468</b>
URB_RRL 1-Urban vs 2-Rural	1.296	
REGION 1-Northeast vs 4-West	0.689	0.988
REGION 2-Midwest vs 4-West	0.884	0.811
REGION 3-South vs 4-West	0.697	1.021
HS_SIZE 1 vs 3	<b>3.039</b>	<b>2.862</b>
HS_SIZE 2 vs 3	<b>1.734</b>	<b>1.415</b>
HHOUSE (1) Owned vs other	<b>1.179</b>	<b>0.796</b>
HHOUSE (2) Rented vs other	<b>2.390</b>	<b>1.150</b>

\*only variables with bolded Odds Ratios are used to create weight adjustment cells in the direct ratio-adjustment method M2 to separately adjust for wireless-only and phoneless households

# Inverse of predicted propensities from these models are used to adjust WTIA weights for adults in LTWI and LTI groups in the method M3

**Table 4: Distribution of adjustment factors to compensate for noncoverage of wireless-only and phoneless households under SP and M1--M3 adjustment methods, 2004 NHIS telephone sample**

Statistics	SP	M1	M2	M3	M2/SP	M2/M1	M2/M3
Minimum	0.534	0.494	0.509	0.53	0.953	<b>1.030</b>	0.960
Maximum	1.706	<b>13.962</b>	<b>12.108</b>	2.913	7.097	<b>0.867</b>	4.157
Median	1.086	1.046	1.05	1.081	0.967	<b>1.004</b>	0.971
Mean	1.069	1.07	1.07	1.07	1.001	<b>1.000</b>	1.000
Std Dev	0.158	0.531	0.527	0.174	3.335	<b>0.992</b>	3.029
Coeff of Variation	14.765	<b>49.669</b>	<b>49.278</b>	16.309	3.337	<b>0.992</b>	3.022
Interquartile range	0.133	0.129	0.141	0.135	1.060	<b>1.093</b>	1.044

**Table 5: Comparison of weighted estimates and their mean-squared errors under SP and M1--M3 methods with the NHIS 2004 estimates among adults aged 18-34 years, 2004 NHIS telephone sample**

Age Group	2004 NHIS		SP		M1		M2		M3		Difference in MSE*			
	EST04	SE04	EST	SE	EST	SE	EST	SE	EST	SE	M1-NHIS	M2-NHIS	M3-NHIS	SP-NHIS
<b>Health Status</b>														
(1) Excellent to good	95.56	0.13	95.97	0.19	95.48	0.28	95.74	0.22	95.87	0.19	0.085	<b>0.081</b>	0.132	0.204
(2) Fair/poor	4.44	0.13	4.03	0.19	4.52	0.28	4.26	0.22	4.13	0.19	0.085	<b>0.081</b>	0.132	0.204
<b>Health Insurance</b>														
(1) Uninsured	27.37	0.34	25.28	0.46	26.43	0.54	26.18	0.55	25.41	0.46	<b>1.175</b>	1.719	4.053	4.580
(2) Insured	72.63	0.34	74.72	0.46	73.57	0.54	73.82	0.55	74.59	0.46	<b>1.175</b>	1.719	4.053	4.580
<b>Private Insurance</b>														
(1) Has private	62.61	0.39	65.68	0.55	63.89	0.66	64.36	0.65	65.4	0.55	<b>2.074</b>	3.485	8.087	9.727
(2) No private	37.39	0.39	34.32	0.55	36.11	0.66	35.64	0.65	34.6	0.55	<b>2.074</b>	3.485	8.087	9.727
<b>Poverty Status</b>														
(1) <100%	14.19	0.41	13.12	0.72	15.25	0.96	14.54	0.84	13.42	0.72	2.045	<b>0.828</b>	1.111	1.663
(2) 100-199%	21.07	0.38	18.95	0.54	20.1	0.68	20.5	0.72	19.06	0.54	1.403	<b>0.843</b>	4.332	4.786
(3) 200-399%	31.83	0.43	32.51	0.67	31.92	0.78	31.89	0.77	32.39	0.67	0.617	<b>0.597</b>	0.763	0.911
(4) 400%+	32.91	0.54	35.42	0.8	32.73	0.86	33.07	0.87	35.13	0.8	0.772	0.783	5.568	6.940

Note: \*MSE=Bias\*\*2 + SE\*\*2 , where Bias = EST – EST04

SP method used age(3),sex(2),race/ethnicity(3) in adjustment

M1 used the direct ratio adjustments for the (WP+NP) group by household size(2), age(2), sex(2), and race/ethnicity(2)

M2 used the direct ratio adjustments separately for the WP group by house tenure, household size, age and race/ethnicity and for the NP group by household size, house tenure, and education

M3 used the propensity score method using 1/propensity as the adjustment factor with

**Table 6: Comparison of the ratios of mean-squared errors (MSE) of population estimates among adults aged 18-34 years using M1--M3 and SP methods, 2004 NHIS telephone sample**

Age: 18-34 Years	Ratio of MSE				
	M1/SP*	M2/SP*	M3/SP*	M2/M1**	M2/M3**
<b>Health Status</b>					
(1) Excellent to good	0.415	<b>0.396</b>	0.647	<b>0.953</b>	<b>0.611</b>
(2) Fair/poor	0.415	0.396	0.647	<b>0.953</b>	<b>0.611</b>
<b>Health Insurance</b>					
(1) Uninsured	<b>0.257</b>	0.375	0.885	1.462	<b>0.424</b>
(2) Insured	<b>0.257</b>	0.375	0.885	1.462	<b>0.424</b>
<b>Private Insurance</b>					
(1) Has private ins	<b>0.213</b>	0.358	0.831	1.680	<b>0.431</b>
(2) No private ins	<b>0.213</b>	0.358	0.831	1.680	<b>0.431</b>
<b>Poverty Status</b>					
(1) <100%	1.230	<b>0.498</b>	0.668	<b>0.405</b>	<b>0.745</b>
(2) 100-199%	0.293	<b>0.176</b>	0.905	<b>0.601</b>	<b>0.195</b>
(3) 200-399%	0.677	<b>0.655</b>	0.837	<b>0.968</b>	<b>0.782</b>
(4) 400%+	0.111	<b>0.113</b>	0.802	1.014	<b>0.141</b>

\*Smaller ratio means higher reduction in bias

\*\*Ratio <1 means that M2 method performed better than the method in denominator