Assessment of Potential Bias in Telephone Survey Estimates due to Noncontact and Noncoverage where Respondents Primarily use Wireless Telephones or do not have Landline Telephones

Meena Khare and Abera Wouhib

Meena Khare, National Center for Health Statistics, 3311 Toledo Road, Room #3112, Hyattsville, MD 20782, mkhare@cdc.gov

Abstract[1]

The quality of survey estimates depends on coverage of the target population, response rates, and measurement errors. Landline telephone surveys exclude households that do not have landline telephones including wireless-only households. Among children under 18 years of age, the prevalence of living in wireless-only households increased from 3.7% in 2003 (January-June) to 19% in 2008 (July-December) according to the National Health Interview Survey (NHIS). In addition, households with mixed telephone service where members primarily use wireless telephones for most calls (wireless-mostly) may not answer their landline telephones which results in survey noncontact. In 2007, wireless-mostly and wireless-only households accounted for 15% and 13% of children under 18 years of age, respectively. In the U.S., the prevalence of the wireless-only and wireless-mostly population has been consistently increasing and may affect the validity of estimates from telephone surveys such as the National Immunization Survey (NIS). Telephone status and interview data for children under 18 years of age from the NHIS-Sample-Child file are analyzed to compare alternative methods to adjust sampling weights and evaluate potential bias in weighted estimates. We used interview data to compare characteristics of children and estimates of selected outcome measures that are associated with health conditions and vaccinations. The purpose of this paper is to evaluate potential bias in RDD survey estimates after adjusting for noncoverage of households that do not have access to landline telephone.

Keywords: Weighting, propensity score models, RDD telephone survey

Introduction

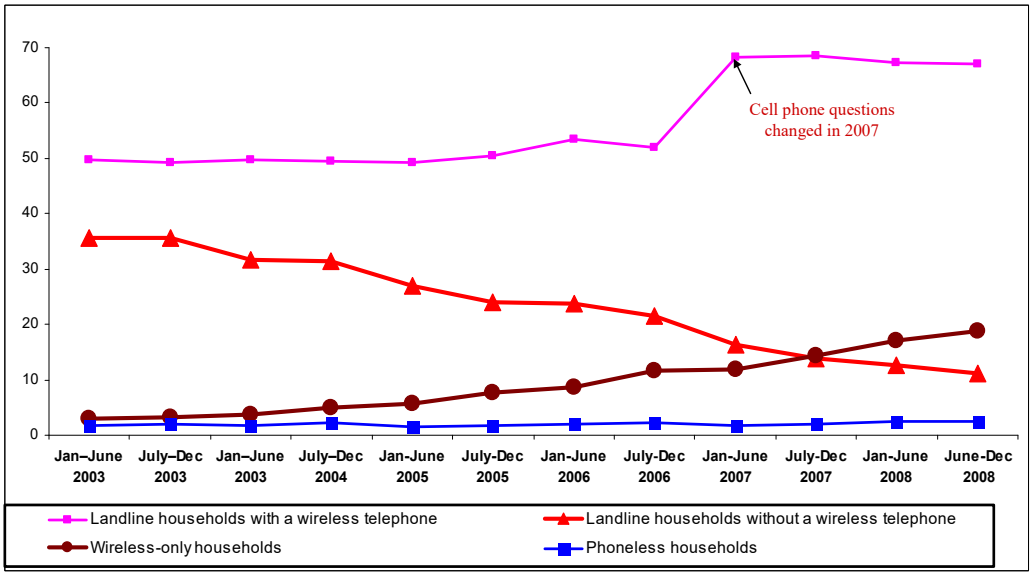
The quality of survey estimates depends on coverage of the target population, response rates, and extent of measurement errors. Response rates for household-based telephone surveys have been continuously declining for the last decade (Battaglia *et al*., 2007, Curtin *et al*., 2005). With rapidly changing technology and telephony, households (i.e., persons) are substituting residential landline telephones with wireless (aka cell-phone or mobile) telephones, and as a result, noncoverage of residential households in landline telephone (LT) surveys has been also increasing (Blumberg and Luke, 2009). Despite all challenges, random-digit-dialing (RDD) landline telephone surveys are still the quickest and cost-effective ways to collect data and investigate emerging public health issues. The goal of the household-based RDD surveys is to produce unbiased national estimates but high noncoverage and nonresponse increase the potential for bias in survey estimates.

Blumberg and Luke (2009a) used data from the National Health Interview Survey (NHIS), which covers both telephone and nontelephone households, to show that trends in wireless substitution among adults increased from 2.9% in 2003 to 18.4% in 2008 while the prevalence of phoneless households remained constant and ranged from 1.6-2.1%. Among households with children under 18 years of age, the wireless substitution increased from 2.9% in 2003 to 18.7% in 2008 while prevalence of phoneless households ranged from 1.5-2.4%. The authors also showed that the prevalence of wireless substitution is higher among certain socio-demographic subgroups: adults aged 25-29 years; men; those living in poverty, renting their home, living alone or living with unrelated roommates; those living in south, and of Hispanic or non-Hispanic black race/ethnicity. Renting home and living alone or living with unrelated roommates are the strongest predictors of wireless substitution. Rates of landline telephone coverage also show substantial variation by state and other geography (Blumberg *et al.,* 2009b). In addition, households with mixed telephone service where members primarily use wireless telephones for most calls (wireless-mostly) may not answer their landline telephones which results in survey noncontact. Adults from wireless-mostly households are more likely to be college graduates, living with children, having higher income, and living in metropolitan

[1] "The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention."

areas (Blumberg and Luke, 2009a). The following chart shows 6-monthly trends in the prevalence household telephone status among households with children under 18 years of age from the 2003-2008 NHIS.

Figure 1: Trends in the 6-Monthly Prevalence of Household Telephone Status among Households with Children Aged <18 Years, 2003-2008 NHIS (source: Blumberg and Luke, 2009a)



In 2007, 15.2%, 13.3% and 13.8% of children under 18 years of age were living in non-landline (NLT), wireless-only (WPO), and wireless-mostly households, respectively. The prevalence of children living in WPO households decreased with increasing age of child and was 20.6%, 11.7 %, and 8.7% among children aged 0-4 years, 5-12 years, and 13-17 years, respectively. The corresponding prevalence of children from NP households was 3.3%, 1.4%, and 1.3% for the three age groups. The prevalence of wireless-mostly did not vary much by age (12.7%, 13.0%, 14.6% for the three age groups, respectively). Since the characteristics of persons living in landline telephone (LT) households is considerably different from the population living in NLT households, estimates from RDD surveys are subject to potential bias due to noncoverage and adjustments are required to compensate for this noncoverage and to reduce bias. The increasing prevalence of the WPO and wireless-mostly populations may affect validity of estimates from telephone surveys such as the National Immunization Survey (NIS; Smith *et al.,* 2005). We used data from the NHIS for the age groups 0-4 years and 13-17 years to assess potential bias in vaccination estimates for age-eligible children from the NIS-Child (19-35 months) and the NIS-Teen (13-17 years) surveys assuming similar nonresponse and noncoverage characteristics for the two surveys.

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 telephone was added to the NHIS and in 2007 another question was added on usage pattern of wireless phones (sometime or most-of the time). Data from the 2007 NHIS-child sample (n=9417, http://www.cdc.gov/NCHS/nhis/nhis_2007_data_release.htm) are used to model and compare characteristics of children living in phoneless (NP) households, wireless-only households (WPO), with children living in landline telephone (LT) households or in households with interruptions (LTI) in landline telephone service. We created six groups based on household telephone status:

1) **LTI** contains children from households which had only LT service at the time of the survey and had interruptions in LT service (I) for one week or more during the previous 12 months;
2) **LTWP-some** contains children from mixed households which had LT service, had no interruption in LT service and also report using wireless phones sometime;
3) **LTWP-mostly** contains children from mixed households which had LT service, had no interruption in LT service, and also report using wireless phones most of the time;
4) **LT-only** contains children from households which had only LT service, had no interruption in LT service, and had no access to wireless phones in the household;

5) **WPO** contains children from households without any LT service during the previous year and which had at least one household member with access to a wireless telephone during that time;
6) **NP** contains children from households with no access to LT or wireless telephone service in the household during the previous year (i.e. phoneless households).

To assess bias, we used variables common to both NIS and NHIS and compared the prevalence of selected health related variables such as Influenza vaccinations and Asthma among children aged 0-4 years, 5-12 years, and 13-17 years. We assumed that the LT sample from the NHIS was similar to a sample from a telephone survey like the NIS; households and children are selected randomly within sampling domains.

Methods

Generally, to reduce bias in survey estimates, sampling weights are adjusted and post-stratified within homogeneous weighting classes to account for interview nonresponse and noncoverage of the target population. Keeter (1995), Brick *et al.* (1996), Frankel *et al.* (2003), and Srinath *et al.* (2002) previously 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 (~4%) are similar to those who live in nontelephone households (~3%); households with interruption of less than one week were assumed to be similar to those with continuous landline service. This is based on the observation that had the survey been conducted at some point in time, when the household had interruptions, the household would have been considered as part of the population of nontelephone households (regardless of access to a wireless telephone). Therefore, persons living in households with an interruption in landline telephone service can be used to represent persons living in nontelephone households in RDD surveys. However, with the recent increase in WPO households, Keeter's interruption method may not be effective when >90% of the noncoverage is due to wireless phone substitution and characteristics of the small LTI population (~4%) might not be the same as the WPO population. Khare *et al.* (2009) and Chowdhury *et al.,* (2007) concluded from their analyses that although some of the characteristics of the LTI or NP household members are similar to those of the WPO household members (e.g., renters or under 200% poverty level), interruption method was not effective in reducing noncoverage bias for exclusion of WPO households. Also, interruption method introduced substantial variation in the final sample weights due to large adjustment factors (e.g., 4% LTI children representing 20% children in the WPO population may increase weights of LTI children by 5folds).

We selected the sample of children under 18 years of age living in LT households from the 2007 NHIS-Child sample to approximate a RDD type sample and evaluated alternate adjustment methods using ratio- and propensity-based weighting methods. We used the nonresponse adjusted interim NHIS weights WTIA_SC (=W_i^B) for the children in the 2007 NHIS-Child LT sample to adjust for noncoverage. To assess bias in the resulting weighted estimates, mean-squared errors (MSE= $\text{Bias}^2 + \text{SE}^2$) are computed with respect to the national estimates from the 2007 NHIS-Child sample and compared ratios of MSEs between methods. The weighting method with smaller MSEs is expected to perform better in reducing bias in estimates.

Method M1 is similar to the interruption method used in the NIS to compensate for the noncoverage of nontelephone households (Frankel *et al.*, 2003; Smith *et al.,* 2005). In method M1, initial weights W_i^B for children from households with interruptions (LTI) are directly ratio-adjusted to the [(LTI) + (NP+WPO)] population control totals (N_i) within the demographic [(age (3), race/ethnicity (3)] weighting cells; no noncoverage adjustments were applied to the sampling weights of children from the LTWP-some, LTWP-mostly, and LT-only households. Thus, the new noncoverage adjusted sampling weight M1 for the unit *i* in the LTI group is defined as

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

Method M2 used a different direct ratio-adjustment procedure. Based on the findings from Khare *et al.* (2009) showed that the characteristics of children living in LT-only households are similar to those who live in WPO households, method M2 separately adjusts sampling weights for children from LT-only households to represent children from WPO households. However, because the proportions and sample sizes of the LTI and NP groups are very small and the children from the two groups had somewhat similar characteristics as the children from the WPO and the LT-only groups, method M2 simultaneously adjusts weights for the children from the combined LTI and LT-only groups for those from the NLT (WPO +NP) group. Hence, weights of the children in the (LT-only + LTI) groups are adjusted to the (LT-only + LTI + WPO + NP)

estimated population control totals within weighting cells based on characteristics [house tenure (2), <200% poverty level (2), and race/ethnicity (3)] associated with WPO and NP phone status; no noncoverage adjustments were applied to the sampling weights of children from the LTWP-some and LTWP-mostly households. Thus, the new sampling weight M2 for the unit *i* in the (LT-only + LTI) group is defined as

$$W_i^{M2,(LT-only+LTI)} = W_i^B * \frac{N_{(LT-only+LTI),ps} + N_{WPO,ps} + N_{NP,ps}}{\sum_{i\in(LT-only+LTI),ps} W_i^B}.$$

An alternative approach to the direct ratio-adjustment method is to use logistic regression to model response propensities of nontelephone status for the LT sample and use the predicted propensities to create weighting classes and adjust sampling weights for noncoverage (Battaglia *et al.,* 1995; Khare and Chowdhury, 2006) within those classes. Method M3 uses data from the 2007 NHIS-Child sample to develop a logistic regression model of response propensities for NLT households consisting of (WPO + NP) households and (LT-only + LTI + LT-mostly) households. The final NLT propensity score model used child's age group(3), housing status(2), region (4), mother's age group (3), mother's marital status(4), and poverty level(4) as covariates. To account for the complex sample design we used normalized sampling weights WTIA_SC in the logistic regression model. Next, WTIA_SC weights for the children from the telephone sample are adjusted within weighting classes based on the quintiles of the predicted propensity scores and selected socio-demographic characteristics [age(3), house tenure(2), and <200% poverty level(2)]; no noncoverage adjustments were applied to the sampling weights of children from the LTWP-some households.

Finally, a poststratification step adjusted the total weighted cell counts for children from the LT sample using methods M1--M3 to the total target US population under 18 years of age within demographic cells [age(3), sex (2), and race/ethnicity(4)]. These final poststratified weights are then used to compute the new noncoverage adjusted estimates which are compared with the overall 2007 NHIS-Child sample estimates.

To compare the three adjustment methods, weighted estimates of selected health related and socio-demographic characteristics are compared. We selected household respondent-reported information on child's access to health insurance, receiving influenza vaccinations, ever having Asthma, and ever having chickenpox to assess bias by taking the difference between the overall 2007 NHIS-Child sample estimates and the estimates from the LT sample using the sampling weights from methods M1--M3. To account for the complex sample design of the NHIS, SUDAAN (RTI, 2008) was used to compute standard errors. Differences in estimates and ratios of estimated MSEs are used to compare weighting methods and evaluate bias.

Results

Characteristics and the prevalence by the type of telephone status

Table 1 shows the prevalence of having or not having access to landline and/or wireless telephones defined by six telephone groups (LTI, LTWP-some, LTWP-mostly, LT-only, WPO, and NP) and by selected child's characteristics. In 2007, among children under 18 years of age, 84.8% lived in LT household, 13.3% lived in WPO household, and 1.9% had no access to phone; 4.1% children lived in households with interruptions of ≥1 week in telephone service in the past 12 months. The WPO group represented 92% of the noncoverage in a landline telephone survey of children. Children from the WPO household are more likely to: be younger (0-4 years); live in rented house; be of Hispanic or non-Hispanic black race/ethnicity; live in the south; have a less educated (≤high school) young mother (≤29 years) who is a single parent (household size=2) and is either never married or widowed/separated/divorced; have no health insurance (i.e., uninsured); and have household income below 200% of the poverty level. Children from LT-only, LTI, and NP households, in general, have similar characteristics as children from WPO households with few exceptions. Children from LTWP-mostly households (~14%) appear to have more overlapping characteristics with LTWP-some households (~52%) than with NLT or LT-only households. It is difficult to estimate the proportion of LTWP-mostly households that do not respond to ringing landline telephone resulting in a noncontact. The LTWP-mostly household respondents are more likely to be home owners, with high education, and have high income. We used these characteristics with high prevalence to develop a propensity score model for noncoverage using a stepwise logistic regression model. The final propensity score model, significant correlates of noncoverage, and parameter estimates are presented in Table 3.

Figure 2 shows variation in the prevalence of selected vaccination related health characteristics by the three age groups and six telephone groups**.** The prevalence of children with influenza vaccination (i.e., flu shots), asthma, chickenpox, and

without health insurance (i.e., uninsured) shows different association with LTI, NP, LT-only, and WPO telephone status in comparison to LTWP-some and LTWP-mostly telephone status by the three age groups.

Propensity score model for NLT households

Table 3 shows the results of the logistic regression model predicting propensity of being a NLT household among LTI, LT-only and LTWP-mostly households. A subset of the variables listed in Tables 1 with large percentages or differences between the NLT and other telephone groups is selected to develop the propensity models; most of these are also available in the NIS. Method M3 used the quintiles of the predicted propensity score to create homogeneous weighting cells and adjusted for noncoverage among the LTWP-mostly, LT-only, and LTI households. It is expected that including the LTWP-mostly group in the model and using house tenure status, mother's education and poverty level may simultaneously adjust for the residual noncontact with the LTWP-mostly households. The first column of Table 3 lists the set of covariates selected from the stepwise logistic regression models (in the order variables entered the model) to predict propensity scores for the NLT status; beta coefficients and estimates of Odds Ratios for the covariates are shown in columns 2 and 3 of the table. Table 3 also shows some model diagnostics. The concordance (69%) and estimated value of 'c', the area under the ROC curve (69%), indicate a moderate association between predicted propensities and observed responses (i.e., indicators of NLT status).

Comparison of adjustment factors and weighted estimates

Table 4 shows the distribution of the overall adjustment factors that are applied to the WTIA_SC weights using methods M1--M3. It shows that methods M2 and M3 performed slightly better than the method M1 (Keeter's method). The maximum adjustment factor using method M1 was ~3 times larger than the maximum factors using methods M2 or M3; The CV from method M1 is also ~2 times larger than other two methods. The ratio of methods M3 to M2 shows that overall both methods performed equally well, however, method M3 performed slightly better than M2 with smaller mean, standard deviation, CV, and inter-quartile range (i.e., with ratios M3/M2<1).

Comparison of weighted estimates and MSEs

Table 5 and 6 present a comparison of the prevalence of influenza vaccinations (i.e., flu shots) among children, 95% confidence interval for the NHIS-Child sample estimates and MSEs (=Bias**2 + se**2) using the 2007 NHIS-Child sample estimates as true population estimates. Table 5 shows that after adjusting sampling weights for noncoverage of NLT households, the bivariate prevalence of influenza vaccinations are not statistically different from the NHIS-Child estimate. The prevalence estimates of influenza vaccinations by the three age groups are also not statistically different from the NHIS-Child estimates. The estimates of MSEs are smaller for methods M2 and M3 than method M1. Although overall weighted estimates using methods M2 and M3 are very close, the ratios of MSE (M3/M2) in Table 5 are slightly smaller for method M2, however, this varies by the three age groups and the characteristics of interest. Table 6 shows a comparison of the ratios of MSEs by three age groups. Method M2 appears to perform better among children of ages 0-4 years (the overall ratio M3/M2>1.0) while method M3 appears to perform better among teens 13-17 years and children aged 5-12 years (the overall ratio M3/M2<1.0) in reducing noncoverage bias.

Conclusion

Our analysis shows that children living in LT-only, LTI, WPO, or NP households have different socio-demographic characteristics than children living in LTWP-some and LTWP-mostly households. The prevalence of children from WPO households decreased with increasing age among children under 18 years of age and also with increasing age of their mother. Other factors that are highly correlated with WPO, LT-only, and NLT status are house tenure, household size, race/ethnicity, poverty level, mother's age, education, and marital status, and geographic region. After adjusting for differential noncoverage, the difference in estimates of household-reported influenza vaccinations with respect to the overall 2007 NHIS-Child sample estimates were 0.08%, -0.01%, and -0.06% (the corresponding maximum differences by subcategories were 2.64%, 1.16%, 1.15%) using weighting methods M1, M2, and M3, respectively. Among the three age groups of children, these differences in influenza vaccinations were 1.68%, 0.99%, and 0.69% among 0-4 year olds, -0.50%, -0.81%, and -0.74% among 5-12 year olds, and -0.58%, 0.23%, and 0.24% among teens 13-17 year olds using the three weighting methods, respectively; none of adjusted estimates are statistically different from the overall NHIS-Child sample estimates.

With increasing trends in the prevalence of wireless only households, using separate adjustments for wireless-only and phoneless household may be desirable and may control potentially larger bias in population estimates that are correlated to characteristics of wireless-only households. Adjustments based on interruption in landline telephone service reduced the noncoverage bias, especially for those characteristics that are highly correlated with the absence of landline telephone or

presence of wireless services but increased variances due to small sample sizes and large NLT adjustment factors. Methods M2 and M3 appear to perform somewhat better than the Keeter's interruption method M1. The ratios of MSE (M3/M2) are >1.0 (Table 6) suggesting slightly greater reduction in bias with method M2 (a hybrid of Keeter's ratio adjustment method). Because method M3 can use more covariates and categories associated with telephone status of households, it may be desirable to use the propensity score method when feasible, to reduce noncoverage bias in RDD estimates. To use methods M2 or M3, RDD surveys need to collect information on household tenure (the most significant characteristic of NP, WPO, LT-only, LTWP-mostly households) and access to wireless telephones by household members.

Annual evaluation of potential noncoverage bias in the NIS is needed as the prevalence of wireless-only households continues to increase. A sensitivity analysis indicates that with a prevalence of 25% NLT households, and a 10% difference between landline and NLT group estimates, the estimated landline noncoverage bias may be as much as 2.5% [= NLT prevalence* (difference in LT and NLT estimates)]. The NHIS provides a unique source of data for this evaluation and could be used in a similar way for other RDD surveys. Findings from the analysis of the NHIS data by telephone status are reassuring, however, direct assessment of bias in RDD surveys like NIS are needed. In 2009, a provider-record-check study has been added to the NHIS for children under 5 years of age and teens of age 13-17 years to directly evaluate noncoverage and nonresponse bias in vaccination estimates from the NIS.

To continue further evaluation of reduction in noncoverage bias with increasing substitution of landline telephones with wireless phones, and to adjust for the noncoverage of wireless-only households in telephone surveys, the 2007 NIS added a question on access to wireless telephones during the interruption in landline service. Also, a pilot study was conducted whereby sample of wireless phone numbers are hand-dialed to interview households with access to wireless phones. In 2008, in addition to socio-demographic and geographic information, NIS has added questions to collect information on household tenure status and access to wireless telephones to identify LT-only households and for direct assessment of potential bias due to noncoverage of wireless-only households; this data collection continued in 2009 NIS. Furthermore, for direct assessment, NIS is also conducting several experiments using dual frame and address-based sampling to cover telephone and non-telephone households in 2009. NIS is also conducting a small wireless telephone survey to compare vaccination coverage estimates from a landline and a wireless telephone survey. NIS is also re-evaluating the household interview weighting procedure to reduce noncoverage bias. Findings from some of these experiments will be available in 2010.

Finally, our analyses had a few limitations. First, we assumed that nonresponse and noncoverage patterns were similar for a traditional RDD sample and the NHIS LT sample. Second, the NHIS conducts in-person face-to-face interviews while RDD surveys collect data through computer-assisted telephone interviews which may cause plausible mode effect in responses. Also, NHIS collects limited information related to vaccinations and therefore it is difficult to do a direct noncoverage bias assessment for the NIS estimates. Lastly, it is difficult to benchmark the NIS estimates to the NHIS estimates due to differences in weighting and estimation procedures.

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Table 1: Prevalence of telephone coverage among US children (age <18 years) by selected characteristics, 2007 NHIS-Child sample (numbers in blue show categories with high proportions)

Characteristics	NHIS-Child sample Distribution		Prevalence by Telephone Status (Children of Age <18 years)					
			LTI (≥1wk)	LTWP-some	LTWP-Mostly	LT-only	WPO	NP
	n	%	%	%	%	%	%	%
All	9417	100.0	4.1	51.8	13.8	15.1	13.3	1.9
Age: 0 - 4 Years	2813	27.9	4.2	43.8	12.7	15.5	20.6	3.3
5 - 12 Years	3778	43.6	3.7	54.0	13.9	15.3	11.7	1.4
13 - 17 Years	2826	28.5	4.6	56.3	14.6	14.5	8.7	1.3
House tenure: Owned	5785	65.9	2.3	62.1	15.2	12.0	7.5	0.8
Rented	3632	34.1	7.5	32.0	10.9	21.1	24.6	3.9
Sex: Male	4865	51.1	4.6	51.1	13.4	15.6	13.7	1.5
Female	4552	48.9	3.5	52.6	14.1	14.6	12.9	2.3
Race/Ethnicity: Hispanic	2870	20.8	4.5	40.7	11.9	21.1	18.2	3.6
NH- White	4282	57.6	3.3	59.6	14.5	11.5	10.1	0.9
NH- Black	1656	15.8	6.6	37.3	13.0	20.9	19.5	2.6
NH- Others	609	5.8	4.0	53.6	15.3	13.4	10.2	3.6
Region: Northeast	1616	16.8	2.8	59.9	11.6	16.9	7.7	1.1
Midwest	1862	23.7	5.5	53.2	12.4	14.4	12.7	1.8
South	3548	36.9	4.3	47.5	15.7	13.1	17.1	2.3
West	2391	22.7	3.2	51.5	13.7	17.8	12.0	1.9
MSA: MSA	8037	83.8	4.1	52.5	14.2	14.5	13.1	1.7
Not MSA	1380	16.2	4.1	48.5	11.6	18.6	14.3	3.0
Mother_educ: < Highschool	1740	15.6	6.7	34.5	7.9	25.6	20.5	4.9
Highschool	2333	24.4	5.1	45.1	12.6	18.6	16.5	2.1
> Highschool	4931	56.2	3.0	60.3	16.1	9.8	10.1	0.9
Mother_Age: <25 Years	760	5.9	7.9	22.4	11.6	17.4	35.1	5.6
25 - 29 Years	1239	13.0	4.3	34.2	14.6	17.5	26.8	2.7
30+ Years	7418	81.1	3.8	56.8	13.8	14.6	9.6	1.5
Mother Mar_Stat: Married	6420	70.8	3.2	56.9	14.2	13.3	11.0	1.4
Wid, Div, or Sep	1046	10.8	6.1	40.7	12.1	17.0	21.2	2.8
Never married	967	8.5	8.4	29.8	10.8	22.7	24.2	4.1
HH _size: 2	724	4.0	5.1	35.3	15.8	17.8	23.9	2.2
3 TO 4	5902	53.2	3.8	51.6	14.2	14.4	14.0	1.9
GE 5	2791	42.8	4.3	53.6	13.0	15.8	11.5	1.8
Poverty_Level: <100%	1747	18.3	8.3	29.3	7.8	25.0	24.0	5.6
100-199%	2288	24.3	5.3	41.1	12.0	19.8	19.6	2.1
200-399%	2817	31.0	2.6	59.9	14.6	12.4	9.8	0.8
400%+	2565	26.4	1.8	67.9	18.6	7.1	4.3	0.4
Uninsured: Yes	935	8.7	4.3	36.0	15.5	19.4	19.8	5.0
NO	8482	91.3	4.1	53.3	13.6	14.7	12.7	1.6

Figure 2: Prevalence of selected health characteristics among children by age group and six type of telephone status, 2007 NHIS-Child sample

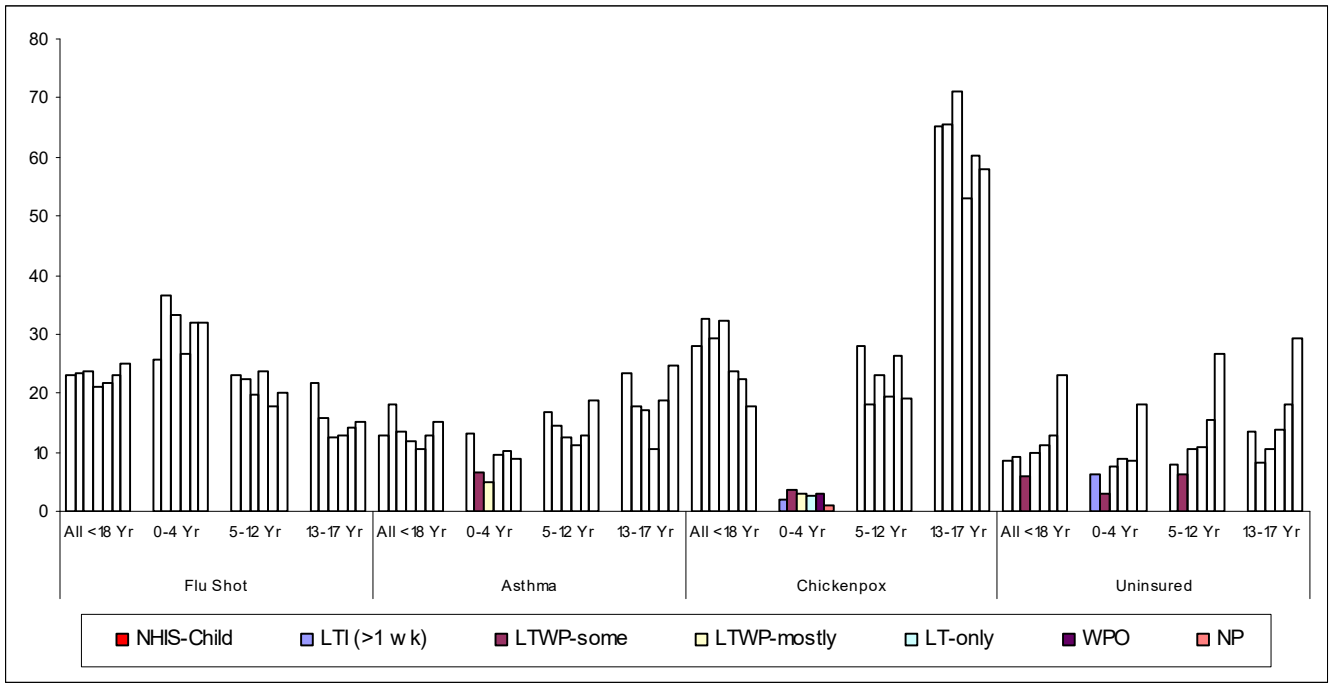

Table 3: Significant covariates, Beta coefficients, and estimates of Odds Ratios from stepwise logistic regression models for predicting propensity scores of combined wireless-only and phoneless status among children (age<18 years) from LTI, LT-only, LT-mostly households, 2007 NHIS-Child sample

Covariates used in the final propensity model (NLT)	Beta coefficient	Odds Ratio (OR)	95% OR LCL	95% OR UCL
Intercept	0.7631			
House tenure: Owner vs Rented	0.3036	1.835	1.569	2.146
Mother_age: 30 + Years vs < 25 Years	0.3784	1.840	1.440	2.351
Mother_age: 25 - 29 Years vs < 25 Years	-0.1470	1.088	0.852	1.389
Mother_Mar_Stat: Married vs Never	0.0875	0.864	0.701	1.065
Mother_Mar_Stat: Wid, Div, and Sep vs Never	-0.3211	0.574	0.447	0.737
Region: Northeast vs West	0.3856	1.330	1.034	1.709
Region: Midwest vs West	-0.1190	0.803	0.654	0.986
Regon: South vs West	-0.3674	0.626	0.523	0.750
Poverty_level: <100% vs 400%+	-0.3374	0.404	0.310	0.527
Poverty_level: 100-199% vs 400%+	-0.2728	0.431	0.337	0.553
Poverty_level: 200-399% vs 400%+	0.0420	0.591	0.459	0.761
Age: 0 - 4 Years vs 13 - 17 Years	-0.3069	0.597	0.480	0.741
Age: 5 - 12 Years vs 13 - 17 Years	0.0971	0.894	0.737	1.083

Quintiles of propensities and age groups are used to create weighting cells and adjust WTIA_SC weights for children in LTI, LT-only, and LT-mostly groups for non-landline status in the method M3

Association of Predicted Probabilities and Observed Responses

Percent Concordant	68.8	Somers' D	0.382
Percent Discordant	30.5	Gamma	0.385
Percent Tied	0.7	Tau-a	0.170
Pairs	3994551	c	0.691

Table 4: Distribution of adjustment factors to compensate for noncoverage of Children from WPO and NP households using M1--M3 adjustment methods, 2007 NHIS-Child LT sample

Statistics	Adjustment Method			Ratio of adjustment factors		
	M1	M2	M3	M2/M1	M3/M1	M3/M2
Minimum	1.1339	1.1032	1.187	0.9729	1.0468	1.0760
Maximum	11.942	3.8183	4.1538	0.3197	0.3478	1.0879
Median	1.2935	1.3328	1.401	1.0304	1.0831	1.0512
Mean	1.5440	1.5462	1.5447	1.0014	1.0005	0.9990
Standard Deviation	1.2262	0.5123	0.4632	0.4178	0.3778	0.9042
Coefficient of Variation (CV)	79.4072	33.1343	29.9868	0.4173	0.3776	0.9050
Inter Quartile Range	0.1195	0.5423	0.4668	4.5381	3.9063	0.8608

Table 5: Comparison of the prevalence for Influenza vaccinations among all children aged <18 years using weighting methods M1--M3, 2007 NHIS-Child sSample (numbers in blue show categories with Ratio of MSEs<1)

Characteristics	NHIS-Child sample: All < 18 Years			Weighting Methods M1--M3							
	Influenza Vaccination Estimate	95% Confidence Limits		LT Sample estimates			MSE*			Ratio of MSE**	
		LCL	UCL	M1	M2	M3	M1	M2	M3	M2/M1	M3/M1
All children <18 years	**22.95**	**21.81**	**24.08**	**22.92**	**22.96**	**23.01**	**0.519**	**0.417**	**0.433**	**0.795**	**0.815**
0-4 years	33.13	30.96	35.38	31.55	32.14	32.43	5.021	2.699	2.282	0.537	0.454
5-12 years	21.69	20.09	23.38	22.20	22.50	22.42	1.275	1.538	1.420	1.206	1.113
13-17 years	14.90	13.26	16.70	15.56	14.66	14.69	1.633	0.965	0.908	0.591	0.556
Asthma: Yes	33.79	30.49	37.09	32.82	34.14	34.3	5.576	3.807	3.829	0.683	0.687
No	21.33	20.15	22.5	21.38	21.33	21.36	0.519	0.429	0.438	0.827	0.845
Chickenpox: Yes	16.58	14.70	18.46	16.22	16.31	16.39	1.293	1.132	1.096	0.875	0.847
No	25.41	24.05	26.78	25.52	25.46	25.54	0.758	0.606	0.615	0.800	0.811
Uninsured: Yes	12.39	9.65	15.14	13.3	12.46	12.78	4.298	2.169	2.578	0.505	0.600
No	23.95	22.75	25.16	23.76	23.9	23.94	0.600	0.473	0.473	0.789	0.789
House tenure: Rented	23.98	22.15	25.8	23.41	23.15	23.46	2.234	1.871	1.52	0.837	0.680
Race/ethnicity: Hispanic	22.39	20.45	24.33	22.18	22.5	22.25	1.964	1.383	1.369	0.704	0.697
NH-White	21.65	20.05	23.25	21.65	21.79	22.09	0.912	0.794	0.998	0.870	1.094
NH- Black	26.07	23.35	28.79	26.29	25.45	25.63	3.794	3.063	2.744	0.807	0.723
NH- Other	29.39	24.58	34.21	28.95	29.42	27.87	8.748	7.879	9.438	0.901	1.079
Poverty_level: < 100%	24.57	21.98	27.16	23.83	24.04	24.41	4.354	2.594	2.381	0.596	0.547
100 - 199%	21.65	19.39	23.9	21.89	22.05	22.29	2.136	1.996	2.335	0.934	1.093
200 - 399%	20.91	19.03	22.79	20.77	21.21	21.12	1.235	1.246	1.222	1.009	0.989
400% +	25.42	23.33	27.52	25.65	25.11	24.94	1.444	1.298	1.429	0.899	0.989
Region: Northeast	27.47	24.71	30.22	27.74	28.01	28.08	2.882	2.747	2.783	0.953	0.966
Midwest	22.43	19.74	25.13	22.11	22.57	22.23	2.691	2.252	2.359	0.837	0.877
South	23.2	21.35	25.05	23.31	23.25	23.53	1.594	1.129	1.277	0.708	0.801
West	19.74	17.84	21.64	19.6	19.13	19.37	1.378	1.526	1.268	1.108	0.921
Mother_educ:											
<HighSchool	21.99	19.48	24.5	23.33	22.55	22.69	5.976	2.953	2.891	0.494	0.484
HighSchool	21.83	19.63	24.04	20.94	21.13	21.2	2.9	2.022	1.973	0.697	0.68
> HighSchool	23.93	22.34	25.53	23.9	24.17	23.9	0.866	0.831	0.743	0.96	0.858
Mother_Mar_stat:											
Married	23.38	22.05	24.71	23.6	23.5	23.37	0.657	0.573	0.572	0.872	0.87
Wid Div Sep	20.28	16.99	23.57	22.46	21.12	20.83	13.043	5.122	4.486	0.393	0.344
Never Married	27.2	23.6	30.81	24.88	26.68	27.71	12.682	5.179	5.493	0.408	0.433
Mother _age: <25 Years	31.2	27.11	35.29	32.95	32.99	32.48	18.254	12.414	10.068	0.68	0.552
25 - 29 Years	27.33	24.17	30.5	24.99	26.17	24.24	9.564	4.72	12.251	0.494	1.281
30+ Years	21.65	20.41	22.89	21.88	21.86	21.87	0.619	0.518	0.528	0.837	0.853

*Smaller MSE means higher reduction in bias, **MSE Ratio <1 means that M2 or M3 method performed better than the method M1

Table 6: Comparison of MSE ratios for influenza vaccinations for selected characteristics and weighting methods by age groups, 2007 NHIS-Child Telephone Sample

2007 NHIS: Prevalence of Influenza vaccinations	All Children <18 years		Age: 0-4 years		Age: 5-12 years		Age: 13-17 years	
	M3/M1	M3/M2*	M3/M1	M3/M2*	M3/M1	M3/M2*	M3/M1	M3/M2*
Total	**0.809**	**1.025**	**0.425**	**0.837**	**1.130**	**0.932**	**0.602**	**0.947**
Asthma: Yes	0.659	0.998	0.283	0.892	1.017	1.129	0.767	0.959
No	0.847	1.024	0.566	0.850	0.912	0.846	0.595	0.945
Chickenpox: Yes	0.834	0.972	1.204	1.066	0.749	1.026	0.922	0.937
No	0.825	1.015	0.450	0.835	1.017	0.881	0.274	0.928
Uninsured: Yes	0.588	1.268	0.912	1.302	0.998	0.991	0.287	0.836
No	0.759	1.001	0.383	0.826	1.128	0.956	0.803	0.955
House tenure: Rented	0.644	0.851	0.580	0.781	0.898	0.887	0.583	0.876
Race/ethnicity: Hispanic	0.695	0.995	0.647	1.192	1.866	1.348	0.687	1.019
NH- White	1.108	1.264	0.756	1.215	1.008	0.998	0.774	0.968
NH- Black	0.762	0.937	0.538	0.821	0.689	0.952	0.480	0.941
NH- Other	1.028	1.187	1.105	1.353	0.770	0.795	0.987	0.859
Poverty_level: < 100%	0.531	0.906	0.413	0.947	0.796	1.091	0.603	0.921
100 - 199%	1.145	1.180	0.919	1.316	0.900	0.805	0.925	0.958
200 - 399%	0.994	0.982	0.708	1.084	1.253	0.971	0.629	0.990
400% +	0.992	1.088	0.893	0.872	0.902	1.004	0.634	0.988
Region: Northeast	0.919	0.964	0.592	0.980	1.238	0.788	0.765	0.907
Midwest	0.859	1.054	0.524	1.011	0.892	0.795	0.844	1.024
South	0.854	1.199	0.490	1.146	1.091	1.463	0.372	0.918
West	0.936	0.860	1.102	0.866	0.761	0.931	0.957	0.944
Mother_Educ: < HighSchool	0.514	1.025	0.650	0.986	0.622	1.342	0.502	0.628
HighSchool	0.614	0.867	0.638	0.772	0.616	1.037	0.727	0.914
> HighSchool	0.912	0.950	0.402	1.037	0.774	0.824	0.811	0.909
Mother _Mar_stat: Married	0.883	1.003	0.780	0.948	0.739	0.770	0.709	0.963
Wid Div Sep	0.353	0.847	0.450	0.960	0.396	0.797	0.616	0.925
Never Married	0.382	1.060	0.443	1.101	0.454	1.124	0.474	0.830
Mother_Age: Less than 25 Yrs	1.122	1.490	1.083	1.429	0.886	1.235	na	na
25 - 29 Yrs	0.468	0.997	0.991	0.745	1.102	0.903	0.974	1.033
30+ Yrs	0.749	0.892	0.399	1.017	0.641	0.888	0.567	0.943

*MSE Ratio <1 means method M3 performed better then M2