Comparison of the Wireless-Only and Landline Populations in a Small Pilot Immunization Study

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Abstract[1]

The size of the wireless-telephone-only population has increased in recent years, raising concerns about the accuracy of RDD-based telephone surveys. Previous research on the impact of wireless-only on population estimates has found mixed results. In 2007, the National Immunization Survey (NIS) conducted a pilot study to determine the impact of wireless-only households on childhood vaccination coverage estimates. The NIS is a nationwide, list-assisted random digit dial (RDD) survey to monitor vaccination coverage among children aged 19 to 35 months. The pilot survey collected vaccination information from 99 wireless telephone users in Illinois. This paper compares vaccination coverage estimates of children in landline households, wireless-only households, and combined. We discuss the implications of these results for RDD surveys and, specifically, for the NIS. Given the extremely low response rate and small sample size of this study, the results presented here should be considered speculative, rather than conclusive, evidence.

Key Words: Cell Phone Survey, Wireless-Only, National Immunization Survey

1. Introduction

The past five years have seen extraordinary growth in the proportion of the population living in homes with only wireless telephone access. During the first half of 2003, 2.9% of adults lived in wireless-only households (Blumberg and Luke 2007a), but by the second half of 2007, the proportion had increased to 12.6% (Blumberg and Luke 2007b).

The massive growth in wireless-only households has led to coverage concerns with random digit dial (RDD) surveys, as these surveys have traditionally excluded wireless telephone numbers. If the characteristics of the wireless-only population are the same as those of the landline population, then the non-coverage of the wireless-only population will not bias our survey estimates. However, if the characteristic of interest varies systematically between the landline and wireless-only populations, then substantial bias can be introduced into survey estimates, and that bias will increase as the proportion of wireless-only households increases. Thus, many RDD surveys have begun experimenting with the addition of wireless telephone numbers to their sampling frame.

The National Immunization Survey (NIS) undertook a pilot survey of children living in wireless-only households and in households with access to both wireless and landline telephones. The primary goal of this pilot was to determine the feasibility of adding a cell phone component to the NIS and to develop operational procedures for such a study. This paper summarizes some of the results of this pilot study in two ways. First, we compare the socio-demographic characteristics and vaccination coverage estimates from the NIS Cell Telephone Pilot Study (NIS-CTPS) to comparable cases drawn from the traditional (landline) NIS survey. Second, we explore the impact on vaccination estimates by combining the traditional landline estimates with the wireless-only subset of the pilot study[2]. Because of small sample sizes and extremely low response rates, the findings presented in this paper on vaccination rates among wireless telephone user are merely meant to be suggestive, rather than conclusive, evidence of the potential impact of wireless households on overall vaccination rates. Both the NIS and NIS-CTPS are sponsored by the Centers for Disease Control and Prevention.

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

[2] Additional bias due to noncoverage may still exist due to households with no phone coverage.

2. Methodology

The NIS is a nationwide survey of households with children between the ages of 19 and 35 months. It is designed to monitor vaccination rates at the national, state, and selective local level. Traditionally, the NIS has employed a list-assisted RDD design to select a sample of residential landline telephone numbers (NIS Data User Guide 2007).

The NIS instrument consists of four main sections. The first section screens the household for the presence of children in the NIS age range and secures the cooperation of the respondent who is most knowledgeable about the eligible child's vaccination history. The second section collects vaccination histories for all eligible children living in the household. Section three then collects a variety of socio-demographic information about the child, mother, and household. And finally, in section four, the instrument gathers information on the medical providers who administered vaccinations to the child and secures consent from the parent to contact those providers in order to verify the child's vaccination history. The vaccination histories reported by the child's providers compose the final vaccination coverage estimates.

In 2007, the NIS undertook a pilot survey of wireless telephones to assess procedures for conducting wireless surveys and to gain practical experience collecting vaccination information via cell telephones. The pilot took place in three separate waves, which are summarized in Table 1. Wave 1 did not collect provider information necessary for calculating vaccination coverage estimates and, thus, is not used for the analysis in this paper. In the next two waves, interviewers from the NIS-CTPS hand dialled 40,041 wireless telephone numbers in the state of Illinois during the second half of 2007 and early 2008. In both waves, a shortened NIS interview was fielded to screen the household, ask several broad vaccination questions, request provider consent, and collect socio-demographic information. Respondents living in both wireless-only households and mixed households (with access to landline and wireless telephones) were interviewed. The interview took approximately 10 minutes to complete.

Table 1: Summary of NIS Cell Telephone Pilot Study Waves[3]

Pilot Wave	Field Dates	Sample Size	N (completes)	N (Adequate Provider Data)	Response Rate (AAPOR RR3)	Summarized Design
Wave 1	8/2007 - 9/2007	9,300	26	NA	20.8%	• Original introduction • Interviewed mother or female guardian • Five dollar incentive • Compressed calling rules
Wave 2	11/2007 – 12/2007	20,075	54	27	17.6%	• Revised Introduction 1 • Interviewed mother or female guardian • Five dollar incentive • Expanded calling rules
Wave 3	1/2008 – 3//2008	19,966	131	72	25.2%	• Revised Introduction 2 • Interviewed mother or father or guardian of either gender • Ten dollar incentive • Expanded calling rules

In this paper, we compare the results from the NIS-CTPS to results from the traditional NIS landline survey. We further divide the NIS-CTPS into two groups: those living in households with only wireless telephone service and those living in households with both landline and wireless service.

[3] The primary purpose of wave 1 was to test systems and procedures. Thus no provider data were collected in that wave and it was not used for vaccination estimation. Therefore, analyses in this paper do not include data from wave 1.

For comparison, the traditional NIS landline results are taken from the 2007Q4 survey and are limited to respondents in the state of Illinois. The NIS landline sample consists of respondents living in households with landline telephones who may or may not have access to wireless telephones and thus, NIS respondents are expected to be comparable to the NIS-CTPS respondents from the wireless with landline group). The field period for the NIS (October 2007-January 2008) partially overlap the NIS-CTPS. Because the NIS contains two estimation areas (IL-Chicago and IL-rest-of-state), appropriate weighting was used to calculate NIS landline estimates comparable to the NIS-CTPS results (which were based on a random sample of all of Illinois).

The NIS-CTPS achieved a low interview response rate (AAPOR RR3) of 21.7% (17.6% for Wave 2 and 25.2% for Wave 3). The comparable NIS landline sample had the interview response rate of 65.3% in Illinois. The NIS-CTPS completed a total of 185 child interviews (63 in wireless-only households, 121 in households with both wireless and landline service). These children were compared to 196 children with completed interviews from the NIS landline survey in Illinois. Of the 185 NIS-CTPS completes, 99 (53.5%) had adequate provider data to calculate vaccination estimates (31 from wireless-only households, 68 from households with both wireless and landline service). From the NIS landline survey 129 (65.8%) children had adequate provider data. The overall provider-level response rate that takes into account the availability of the adequate provider data for the NIS-CTPS was 11.6% while the comparable NIS landline response rate was 43.0%.

3. Results

Although NIS-CTPS experienced low response rates, for assessing differences between samples, Table 2 compares each of the NIS-CTPS groups to the NIS landline survey on a variety of demographic factors. The first set of columns displays estimates and standard errors while the second set of columns displays p-values for pairwise chi-square comparisons between each of the groups (only p-values less than 0.1 are displayed; p-values less than 0.05 are highlighted).

Three significant differences (at alpha=0.05) were found between the wireless-only and wireless with landline groups (on Hispanic status, household size, and years of school). The difference in the Hispanic distribution was quite large, with the wireless-only households having more than twice as many Hispanic children as the other groups. Only one significant difference was found between the landline and wireless-only groups; the wireless-only group had relatively less schooling than those from the NIS landline survey. No significant differences were observed between the landline and wireless with landline groups on these variables.

Table 2: Comparison of Socio-Demographic Characteristics of Children with Adequate Provider Data from the NIS and NIS-CTPS with Provider Data, Illinois

	Estimates			**Percentage Point Difference**		
	NIS	**NIS-CTPS**				
	Landline (n=129)	Wireless w/landline (n=68)	Wireless-only (n=31)	NIS Landline - CTPS Wireless w/landline	NIS Landline - CTPS Wireless-only	CTPS Wireless w/landline - CTPS Wireless-only
Hispanic	15.3% ± 0.06	20.6% ± 0.1	41.9% ± 0.18	-0.05	-0.27	-0.21*
Race						
White	72.9% ± 0.08	59.3% ± 0.13	75.0% ± 0.17	0.14	-0.02	-0.16
Black	11.5% ± 0.06	22.0% ± 0.11	14.3% ± 0.14	-0.11	-0.03	0.08
Other	15.6% ± 0.1	18.6% ± 0.1	10.7% ± 0.12	-0.03	0.05	0.08
Avg. HH Size	4.49 ± 0.24	4.85 ± 0.42	4.03 ± 0.56	-0.36	0.46	0.82*
Avg. Income	$ 26,269 ± $3,888	$ 24,669 ± $5,149	$ 25,536 ± $6,614	1600	733	-867
Avg. Yrs of School	14.6 ± 0.47	14.1 ± 0.71	12.7 ± 0.73	0.50	1.90*	1.40*

* $p < 0.05$.

Table 3 examines the differences in vaccination coverage rates by telephone status. Here we find differences between the landline and wireless w/landline groups on almost every vaccination estimate (ranging from 8- 25 percentage points). Of the 12 vaccine up-to-date indicators in Table 3, only PCV and influenza are not statistically significant at the 0.05 level. No significant differences were found between the wireless-only group and either the landline or wireless w/landline group. Difference in coverage estimates between wireless-only and landline groups ranged from 0-7% except for influenza.

Table 3: Comparison of Vaccination Coverage Estimates from the NIS and NIS-CTPS, Illinois, 2007

	Vaccination Coverage Estimates			Significance Test (p)		
	NIS	NIS-CTPS				
	Landline (n=129)	Wireless w/landline (n=68)	Wireless-only (n=31)	NIS Landline vs. NIS-CTPS Wireless w/landline	NIS Landline vs. NIS-CTPS Wireless-only	NIS-CTPS Wireless w/landline vs. NIS-CTPS Wireless-only
4:3:1:3:3:1:3 [a]	87% ± 5.9%	65% ± 11.7%	84% ± 13.7%	0.22*	0.03	-0.19
4:3:1:3:3:1	90% ± 5.1%	66% ± 11.5%	84% ± 13.7%	0.24*	0.06	-0.18
4:3:1:3:3	91% ± 5.%	66% ± 11.5%	84% ± 13.7%	0.25*	0.07	-0.18
DTaP (4+ doses)	88% ± 5.8%	66% ± 11.5%	84% ± 13.7%	0.22*	0.04	-0.18
DTaP (3+ doses)	96% ± 3.6%	82% ± 9.3%	94% ± 9.2%	0.14*	0.02	-0.12
Polio (3+ doses)	96% ± 3.3%	85% ± 8.6%	97% ± 6.6%	0.11*	-0.01	-0.12
MCV (1+ dose)	96% ± 3.4%	88% ± 7.9%	94% ± 9.2%	0.08*	0.02	-0.06
HIB (3+doses)	95% ± 3.9%	85% ± 8.6%	97% ± 6.6%	0.10*	-0.02	-0.12
Hep B (3+ doses)	96% ± 3.4%	88% ± 7.9%	94% ± 9.2%	0.08*	0.02	-0.06
VRC (1dose)	95% ± 3.9%	85% ± 8.6%	97% ± 6.6%	0.10*	-0.02	-0.12
PCV (3+ doses)	81% ± 6.9%	72% ± 10.9%	81% ± 14.7%	0.09	0.00	-0.09
Influenza	37% ± 9.6%	24% ± 12.8%	25% ± 18.7%	0.13	0.12	-0.01

[a] Vaccine series denotes doses of DTaP:Polio:Measles (MCV):HIB:HepB:Varicella (VRC):Pneumococcal (PCV); see DHHS, 2007
* $p<0.05$

3.1 Impact of Combining Landline and Wireless-Only Estimates

We evaluate the overall NIS estimates by combining wireless-only (NIS-CTPS) with NIS landline samples. Wireless telephones create non-coverage issues to the extent that households cease to utilize landlines and are thus unreachable in a traditional RDD (landline) survey. Thus, by combining results from landline and wireless-only households, the potential non-coverage bias is expected to reduce or be eliminated[4].

The potential impact of wireless-only households on a combined landline and wireless-only estimate can be evaluated using equation (1) below. Simply put, the value of the combined estimate is equal to the sum of the landline estimate times the proportion of the population that has a landline and the wireless-only estimate times the proportion of the population that is wireless-only.

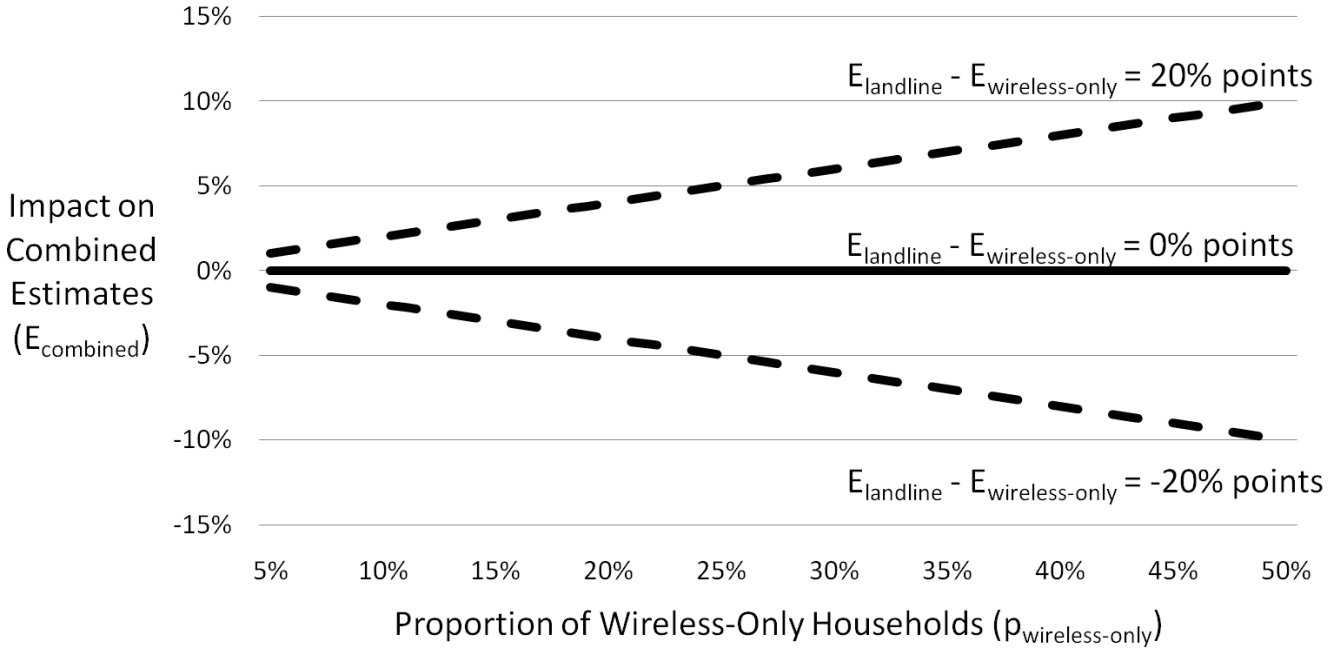
$$E_{(combined)} = (E_{(landline)} \bullet P_{(landline)}) + (E_{(wireless\text{-}only)} \bullet P_{(wireless\text{-}only)}) \quad (1)$$

Figure 1 shows the potential impact on combined estimates that include the landline and wireless-only estimates. Regardless of the proportion of the population that is wireless only, there may be cases where there is no difference between the landline and wireless-only estimate (the central, solid line), If, however, there were a hypothetical 20 percentage point difference in the landline and wireless estimates, then the difference between the combined and landline-only estimates would grow correspondingly as the proportion of the wireless-only population grew. In the

[4] This does not preclude the possibility that wireless phones introduce other survey error, such as if the possession of a wireless phone lowers the propensity to respond to a survey via a landline.

hypothetical example presented in Figure 1, the landline estimate would vary by +/- 10 percentage points if the wireless-only household population represents 50% of the total population and the difference in the landline and wireless-only estimates would be 20 percentage points (the dashed lines).

Figure 1: Theoretical Impact of Combined Landline and Wireless-Only Estimates versus Landline Estimates



Currently, statistics on the prevalence of the population living in wireless-only households are only available at the national level and varies substantially at the local level. Thus, any combined wireless-only and landline estimate at the local level must assume a specific wireless-only prevalence. A number of methods have been suggested for such approximation, but an exploration of these methods is beyond the scope of this paper. In Table 4 and Figure 2 we provide a number of estimates based on a range of assumed wireless-only prevalence: 11%, 16%, and 20%.

Figure 2: Combined 4:3:1:3:3:1:3 Estimates for NIS-Landline, Wireless-Only and Combined Sample

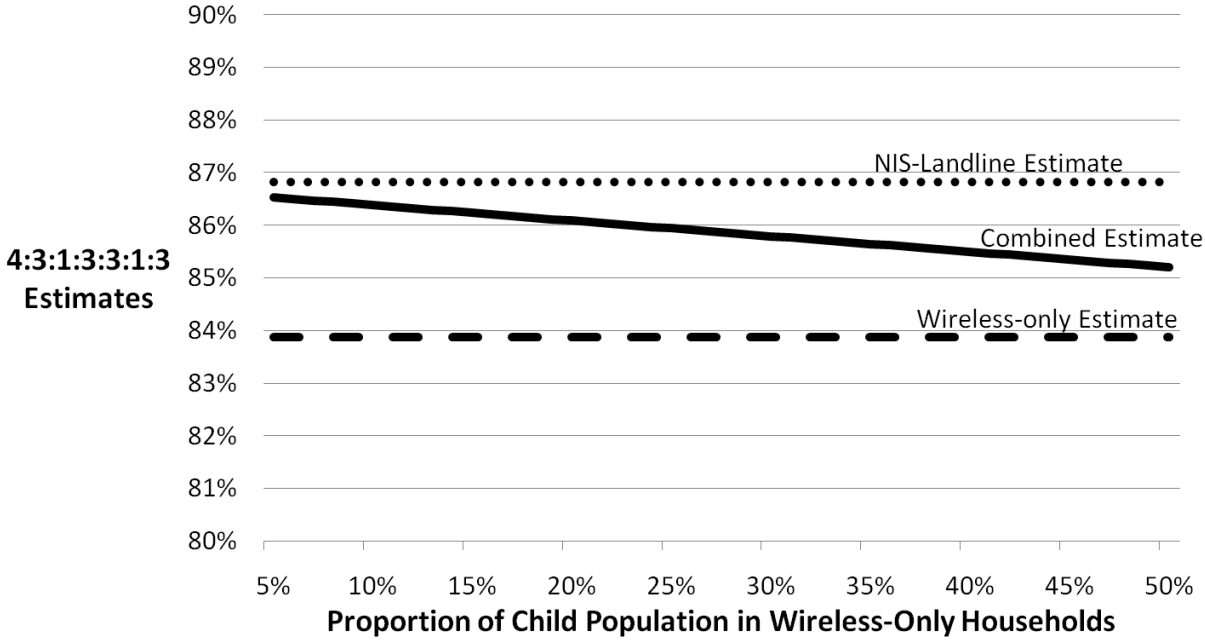


Figure 2 displays the NIS-landline survey estimate, wireless-only estimate, and combined estimate for all possible wireless-only prevalence between 5% and 50%. The landline estimate (87%, the upper dotted line) is three percentage points higher than the wireless-only estimate (84%, the lower dashed line). Thus, as the assumed wireless-only population percentage increases, the combined estimate decreases (the central, solid line).

Table 4 shows the landline, wireless-only, and combined estimates for the each of the 12 vaccination estimates originally shown in Table 3, and for three different assumptions about the population of wireless-only households. We begin with the overall estimate of wireless-only households for the entire U.S. population (15.8%) based on data from the National Health Interview Survey. But as mentioned previously, the NIS is only interested in the relatively rare population of households containing children 19-35 months old. An estimate of the proportion of wireless-only households among NIS eligible households can be derived by combining information from the NHIS and NIS-CTPS Study. The NIS-CTPS found 34.1% of completed interviews were from wireless-only households whereas 74.6% of the NHIS of households reported having at least one wireless phone. It thus follows that the wireless-only rate for NIS eligible households may be as high as 25% (74.6%*34.1%). However, this is likely an overestimate since many authors have noted the higher propensity among cell-only households to answer their cell phone and thus the 34.1% may be too high. Thus, for this paper we assume 16% (slightly higher than national estimate) and plus-or-minus 5% (i.e. 11% and 21%) prevalence for wireless-only households.

The result shows that, with the exception of Influenza and 4:3:1:3:3 coverage estimate, all combined estimates are within one percentage point of the NIS landline estimate. Further, the estimates are not sensitive to changes in the assumed wireless-only prevalence. The vaccine-specific combined estimates assuming a 11% wireless-only prevalence are consistently within 1 percentage point from the combined estimate assuming a 21% wireless-only prevalence.

Table 4: Vaccination Coverage Estimates from the NIS, NIS-CTPS Wireless-Only and Combined Samples by Assumed Percentage of Wireless Population, Illinois, 2007

	Individual Estimates		Combined Estimates		
	NIS	NIS-CTPS	Assumed Wireless-only Population %		
	Landline (n=129)	Wireless-only (n=31)	11%	16%	21%
4:3:1:3:3:1:3[a]	87%	84%	86%	86%	86%
4:3:1:3:3:1	90%	84%	89%	89%	89%
4:3:1:3:3	91%	84%	90%	89%	89%
DTaP (4+ doses)	88%	84%	87%	87%	87%
DTaP (3+ doses)	96%	94%	95%	95%	95%
Polio (3+ doses)	96%	97%	96%	96%	96%
MCV (1+ dose)	96%	94%	96%	95%	95%
HIB (3+doses)	95%	97%	95%	95%	95%
Hep B (3+ doses)	96%	94%	96%	95%	95%
VRC (1dose)	95%	97%	95%	95%	95%
PCV (3+ doses)	81%	81%	82%	82%	82%
Influenza	37%	25%	34%	34%	34%

[a] Vaccine series denotes doses of DTaP:Polio:Measles:HIB:HepB:Varicella(VRC):Pneumococcal (PCV); see DHHS, 2007

4. Limitations

The results summarized in this paper suffer from several major limitations. First and foremost, from the NIS-CTP, only 99 cases with completed interviews had adequate provider-reported data. Of those completes with adequate provider data, only 31 cases were from wireless-only households. This requires large differences between populations in order for the difference to be viewed as significant.

The low response rate is another major limitation. The NIS-CTPS achieved the overall interview response rate of 21.7% (AAPOR RR3) due to lower screener, eligibility, and interview completion rates (Barron *et al*., 2008) and 11.6% provider-level response rate due to lack of permission to contact provides and provider non-response. Though in line with response rates of other cell phone studies, the low response can introduce non-response bias into survey estimates.

5. Discussion

This paper summarizes the results of the National Immunization Survey's Cell Telephone Pilot. The primary goal of the NIS-CTP was to determine the feasibility of adding a cell phone component to the NIS and to develop operational procedures for such a study. The interview and provider response rates were found to be extremely low in the NS-CTPS, therefore, our findings regarding vaccination rates among wireless users should thus not be viewed as conclusive evidence of the impact of wireless households on overall vaccination rates. Instead, we find these results to be suggestive of potential issues that future, larger studies may find. Later studies will need to examine these issues and further examine the viability of cell phone surveys in light of the low response rates

The results of this preliminary pilot show few differences between the demographic characteristics of those interviewed via wireless phone and those interviewed in the traditional landline survey; however, differences were observed between the NIS landline estimates and combined wireless with landline estimates for virtually all types of vaccines and vaccine series. These findings, however, must be interpreted with caution in light of the limited sample size of the wireless-only and wireless with landline groups due to low response rates.

When vaccination coverage estimates were adjusted to cover both the landline and wireless-only population, very few differences in estimates were found. Though estimates of influenza up-to-date status dropped by approximately three percentage points, this seems to be an outlier. For all of the remaining vaccines and vaccine series, adding wireless-only to landline estimates changed estimates by no more than one percentage point. These results are similar to the earlier research by Khare et al. (2007, 2008) that found minimal bias in estimates due to exclusion of wireless-only households from an RDD frame using data from the 2006 National Health Interview Survey (http://www.cdc.gov/nchs/about/major/nhis/nhis_2006_data_release.htm). However, we again point out that these results are based on a preliminary pilot test with an extremely small sample size and low response rate and may question the viability of adding an ongoing cell component to the NIS. Additional unmeasured bias may also exist due to noncoverage of households without any telephone service. Thus, it is uncertain that these results would be replicated by a larger survey or, more importantly, that these estimates accurately reflect the true population vaccination coverage.

The research presented here represents the first step in the National Immunizations Survey's Cell Telephone Research. A larger pilot to compute national vaccination estimates for children living in wireless-only households is currently planned for the first quarter of 2009.

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