A Comparison of Listed and Unlisted Households on Nonresponse and Measurement Error

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Abstract [1]
This paper compares characteristics of listed and unlisted telephone households in their propensity to respond to survey requests and the quality of data provided. We studied these differences in the context of the National Immunization Survey (NIS). The NIS—a nationwide, list-assisted random digit-dialing (RDD) survey sponsored by the Centers for Disease Control and Prevention—monitors the vaccination rates among children aged 19-35 months. Our results showed that listed households yielded a higher screener completion rate and interview completion rate, but a lower resolution rate than unlisted households. Furthermore, responses from listed households are found to have less misreporting of vaccinations and fewer missing data than unlisted households.

Key Words: Listed households, nonresponse, measurement error, data quality, NIS

1. Introduction

Household surveys employing random-digit-dial (RDD) sampling have become increasingly difficult to conduct. First, there is an increased undercoverage due to a growing number of households with only a wireless telephone. Recent government statistics showed that samples resulting from RDD sampling missed about 15.8 percent of households with access only to wireless telephone (Blumberg and Luke, 2008). In addition, about 2.2 percent of households did not have any telephone service (Blumberg and Luke, 2008). If these "wireless-only households" or "no-telephone households" differ from households with a landline telephone in key statistics, there exists potential for coverage bias due to exclusion of wireless-only households and no-telephone households from the sampling frame.

Second, household surveys of RDD samples show a trend in declining response rates over the past few decades (Atrostic *et al.*, 2001; Battaglia *et al.,* 2008; Curtin *et al.*, 2005). The declining response rates pose a risk of nonresponse error if responding households are consistently different from nonresponding households on key analytic variables of interest. One contributing factor to the low response rates for RDD surveys is that little is known about the owner of the telephone number and the household associated with the telephone number before interviewers start dialing. The "cold-call" contacts are generally less likely to lead to cooperation from households (Traugott, *et al.*, 1987). To increase the productivity of RDD samples, it is not unusual for survey organizations to match the randomly generated telephone numbers to white page directories. Those telephone numbers that can be matched to the white pages are labeled "listed households," whereas those without a match are considered "unlisted households." With listed households, survey organizations have the ability to implement various proactive strategies to encourage participation (such as mailing advance letters and/or incentives). Survey literature showed that samples of listed households produced higher overall response rates than RDD samples (Smith *et al.*, 2003; Traugott and Goldstein, 1993; Wilson *et al.*, 1999).

Another contributing factor to the low response rates of surveys using RDD samples is the high proportion of non-working telephone numbers. Even though techniques have been used to reduce the extent of non-working telephone numbers in telephone banks to be sampled from (e.g., listed-RDD sampling), generally RDD samples include more "business numbers," "fax/modem," "disconnected numbers," and numbers not in service than samples of listed telephone numbers (Oldendick and Lambris, 2006; Smith *et al.*, 2003). The high proportion of non-working telephone numbers in RDD samples translates into a low contact rate and increasing cost in screening for residential households.

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

The noncoverage and nonresponse problems of RDD surveys threaten the validity of survey estimates using RDD samples, and the high cost of screening for residential households raises questions on the practical value of using RDD samples. One possible alternative to increase response rates and improve the efficiency of RDD samples is to oversample telephone numbers of listed households in a dual-frame design that employs both RDD sampling and commercial lists of residential telephone numbers (Srinath *et al.*, 2005; Traugott *et al.*, 1987). Besides the possibility of producing high contact rates and high response rates, this alternative may also result in some savings in field cost; empirical evidence demonstrated that listed telephone numbers required significantly fewer call attempts to obtain a completed interview than unlisted telephone numbers (Oldendick & Lambris, 2006; Smith *et al.*, 2003; Traugott & Goldstein, 1993; Wilson *et al.*, 1999).

Oversampling listed households has the potential to lower the extent of nonresponse error by decreasing nonresponse rates and to reduce the field cost by cutting down the number of unproductive calls made to screen out nonworking numbers and to solicit cooperation. However, it is important to evaluate the measurement error and nonresponse error properties associated with listed and unlisted households together in order to have a better understanding of the overall effect of oversampling listed households on total survey error of the estimators.

No research has been done yet to evaluate the measurement error of listed households versus unlisted households. This paper has two goals. First, we compared listed households with unlisted households on indicators of response and cost. Specifically, we examined whether listed households differ from unlisted households in resolution rates, screener completion rates, and interview rates. As an indirect measure of field cost, we compared the average number of call attempts to a completed interview by the listed status of households. Second, we evaluated measurement error in responses given by listed and unlisted household respondents. The overall item nonresponse rate is one of the two data quality indicators that we studied. Item nonresponse reduces the effective sample size, further distorts the representativeness of the sample, and threatens the validity of the results if item nonresponse produces nonignorable missing data (see Little & Rubin, 1987). The general thinking about item nonresponse is that the more missing data there are, the worse the data quality. The second data quality indicator is the percentage of household responses that did not agree with external data. If external data are treated as the "gold standard," then the extent of inconsistency between household responses and external data reflects the extent of measurement error in the household responses. Again, the more inconsistent responses there are, the worse the data quality.

2. Data and Methods

For this study, we used data from the 2007 National Immunization Survey (NIS). The NIS is a nationwide, list-assisted random digit-dialing (RDD) survey sponsored by the Centers for Disease Control and Prevention. It monitors the vaccination coverage rates among children between the ages of 19-35 months. It uses a nationally representative quarterly data collection cycle and produces bi-annual vaccination coverage estimates at the national, state, and local area levels.

Each year, the NIS dials approximately 4.5 million telephone numbers and conducts interviews with approximately 24,000 households across the United States. Before telephone numbers are released to the telephone center, they are sent to GENESYS system (HTTP://WWW.M-S-G.COM) to exclude the business, nonworking, and fax/modem numbers. During this step, GENESYS also identifies telephone numbers that are listed in 'white page' directories. Telephone numbers are flagged by their listed status before being released to the telephone center.

We limited our analyses to the second quarter of 2007 NIS. In this quarter, 854,162 telephone numbers were dialed, 4,314 households completed interviews producing 4,338 children with completed interviews.

During the household interview, household respondents were asked whether they had a written record (shot card) of the child's vaccination history, and whether they were easily accessible. If a shot card was available, the household respondent was asked to provide information directly from it. But if the child did not have a shot card or the shot card was not easily accessible, the household respondent was asked to recall from memory information about the child's vaccinations. In quarter two of 2007, a shot card was used on 30.8% of children from listed household respondents and 27.1% of children from unlisted household in answering questions about vaccination; this difference is not statistically significant at p=.05.

We took advantage of a special design feature of the NIS for this paper. The NIS asked household respondents for their permission to contact the providers who administered vaccinations to their children. We then sent a mail survey to providers for whom we obtained household consent. For this study, we treated providers' report from the mail survey as a "gold standard" and compared household responses to the provider report. We acknowledge that provider reports are not error free; as a matter of fact, some providers did not return the mail questionnaire and some returned the mail questionnaire but did not provide enough information for comparison. We limited our analyses to children for whom adequate provider report had been received. The consent rate to contact the child's provider is 79.6 percent for children from listed households and 77.6 percent for children from unlisted; the difference is not statistically significant at p=.05 level. Adequate provider data are available for 67.0 percent of children from listed households and 64.3 percent of children from unlisted telephone households; this difference is not statistically significant at p=.05 level.

To answer the first research goal, we calculated various key indicator rates for listed households and unlisted households separately and conducted significance tests on the differences. To estimate cost differences, we calculated the average number of calls to a completed interview and working residential number rates separately for listed telephone numbers and unlisted telephone numbers.

To answer the second research goal, we created two different indicators to show data quality. The first indicator is item nonresponse rate. We first selected a set of 24 key questions that all respondents should answer (The list of questions used in computing the item nonresponse rate is listed in the Appendix). We then counted the number of questions to which respondents did not provide an answer and divided the number by the number of questions they should have answered (in this case, 24 for everyone) to get the overall item nonresponse rate. We then compared this item nonresponse rate for listed and unlisted households. For the second data quality indicator, we examined the extent of mismatched responses between household report and provider report on children vaccination by the listed status of households.

3. Results

3.1 Prevalence of Listed Households

We first checked the extent of listed households in the quarter two sample from 2007 NIS. Quarter 2 released 833,588 telephone numbers. About 39.5 percent of these numbers (329,032 telephone numbers) are listed. This rate is similar to what is documented in the literature (Smith *et al.*, 2003).

3.2 Response Rates and Cost by Listed Status

For the NIS, a released telephone number has to be resolved first to determine its residential status, and, if it is a residential telephone number, it is screened to see whether the household has any children of age between 19 and 35 months. A household interview is then attempted on households with age-eligible children. We think it is useful to compare listed and unlisted households on their performance in all three stages. Therefore, we computed the resolution rates, screener completion rates, and the main interview completion rates for these two types of households. As shown in Figure 1, listed households have a significantly lower resolution rate than the unlisted ones (73.7% for listed households and 86.7% for unlisted households). However, the listed households exhibited a significantly higher screener completion rate (90.5% for listed and 84.8% for unlisted) and main interview completion rate (88.2% for listed and 82.4% for unlisted). This is consistent with survey literature (Smith *et al.*, 2003; Traugott & Goldstein, 1993; Wilson *et al.*, 1999). The relatively higher resolution rate and lower screening or interview rates with the unlisted households are largely driven by the fact that unlisted telephone numbers are mostly nonworking or business numbers that can be easily resolved and may use call screening devices to avoid answering incoming telephone calls

However, the overall CASRO response rate (computed as the product of resolution rate, the screener completion rate, and the main interview completion rate) for this quarter did not differ much (~2%) for listed and unlisted households (58.8% for listed telephone numbers and 60.6% for unlisted).

To estimate differential costs associated with obtaining completed interviews from listed and unlisted households, we compared the average number of call attempts to completed interviews by listed status of households. Consistent with existing literature, listed households required significantly fewer number of calls to complete an interview than unlisted households; the average number of calls to completed interviews was 15 for listed households and 18 for unlisted.

Another useful cost measure is the rate of working residential numbers (WRN), that is, the proportion of telephone numbers that are classified as working residential numbers. Not surprisingly, the listed households had a significantly higher WRN rate than the unlisted ones (64% for listed telephone numbers and 6% for unlisted telephone numbers). The WRN rates suggest that samples of listed households are much more efficient than samples of RDD (or samples of unlisted households) in terms of finding residential households. Both findings suggest the gains in field cost in using telephone numbers of listed households.

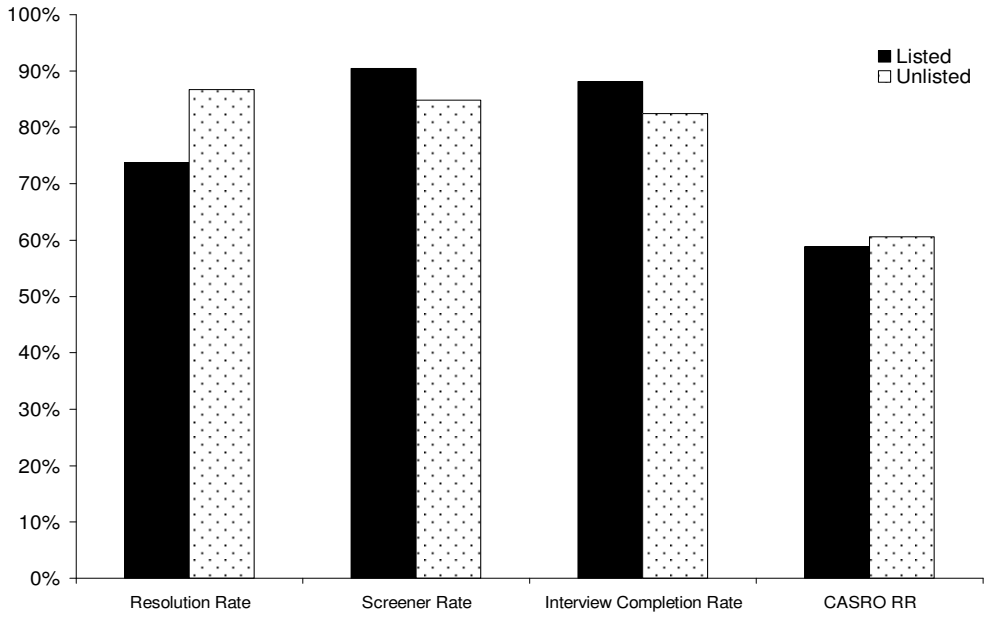

Figure 1. Key Indicator Response Rates by Listed Status of Telephone Households, NIS Q2/2007
Source: CDC, NCRID and NCHS (2008), 2007 National Immunization Survey.

3.3. Data Quality by Listed Status of Telephone Households

3.3.1 Item nonresponse rate by listed status of households and by use of a shot card

We computed item nonresponse rates for 24 questionnaire items separately for listed and unlisted households. The average item nonresponse rate was 2.7 percent for listed households and 3.0 percent for unlisted households. However, the difference is not statistically significant. We further divided the sample by whether an immunization shot card was used in answering 7 of the 24 questions. As shown in Table 1, use of a shot card itself has a significant main effect on the average item nonresponse rate even though the shot card only affects responses on 7 of the key questions. However, there is neither a significant main effect of listed status of the households nor a significant interaction of use of a shot card and the listed status.

Table 1: Item Nonresponse Rates by Listed Status of Telephone Households and Use of a shot card*, NIS Q2/2007

	Used a shot card (%)	Did not use a shot card (%)	Overall (%)
Listed households	1.8	3.1	2.7
Unlisted households	2.2	3.3	3.0
Overall	1.9	3.1	

*30.8% among listed and 27.1% among unlisted households
Source: CDC, NCRID and NCHS (2008), 2007 National Immunization Survey.

3.3.2 Inconsistent responses between household responses and provider report on vaccinations

We compared inconsistent responses in two different ways. First, we examined the percentage of inconsistent responses for each of the six vaccines. That is, if a household respondent reported that their child(ren) received one or

more doses of a vaccine (or did not receive any) but the provider data show that vaccine was *not* administered (or *was* administered), that was counted as an instance of inconsistent response. In other words, the child's vaccination status given by the household respondent did *not* match what the provider record said. Table 2 displays the percentage of children for whom the household responses did not match the provider report by the listed status of households. For instance, 1.2% of children from listed households had inconsistent responses on DT/DTP/DTaP when a shot card was used and none of the children from unlisted households had inconsistent responses on that vaccine. By contrast, when a shot card was not used, 2.1% of children from listed households and 3.3% of children from unlisted households had responses that did not match with the provider records. It seems that, when a shot card was used, the percentage of children from listed households who had inconsistent responses did not differ significantly from that of children from unlisted households. However, when a shot card was *not* used, more children from unlisted households had inconsistent responses than children from listed households; the difference is significant at $p = .05$ level for three of the six vaccines (i.e., MCV/MMR, Hib, and Hepatitis B). It seems that fewer children from listed households had inconsistent responses than children from unlisted households. In addition, the use of a shot card helped remove inconsistencies, a finding consistent with previous work on the quality of household report (Khare *et al*., 2001).

Table 2: Percentage of Inconsistent Responses by Listed Status of Telephone Households, by Vaccine Type, NIS Q2/2007

	Used a shot card		Did not use a shot card		Overall	
Type of Vaccines	Listed (%)	Unlisted (%)	Listed (%)	Unlisted (%)	Listed (%)	Unlisted (%)
Sample Sizes	877	124	1665	289	2542	413
DT/DTP/DTaP	1.2	0	2.1	3.3	1.8	2.3
OPV/IPV	3.3	3.5	9.9	11.2	7.8	8.4
MCV/MMR	9.4	9.2	*7.5*	*11.2*	8.2	10.6
Hib	2.1	2.5	*9.3*	*13.7*	*6.6*	*10.1*
Hepatitis B	2.7	4.1	*4.8*	*8.1*	*4.0*	*6.8*
Varicella	10.2	11.7	12.9	16.9	12.0	15.3

Source: CDC, NCRID and NCHS (2008), 2007 National Immunization Survey.

For each child report given by a household respondent, regardless of its listed status, we summed up the number of times the household respondent produced inconsistent responses on that child's vaccination (The maximum number of times a child's vaccination could be misreported is 6, which means the household respondent misreported that child's vaccine receipt status on all six vaccines.) We then compared the average number of times a household respondent misreported the child's vaccination status when compared with the provider report by the listed status of the household. As seen in Table 3, the listed status had a significant main effect on the average number of inconsistent responses ($F(1, 4434) = 4.38$, $p = .04$); children from the listed households had inconsistence response 1.9 times whereas children from unlisted households had 2.2. The use of a shot card also had a significant main effect on the average number of inconsistent responses, but there is no significant interaction between the two. Table 3 seems to suggest that the use of a shot card reduced more inconsistent responses for children from listed households than for children from unlisted households.

Table 3: Average Number of Inconsistent Responses by Listed Status of Telephone Households, By Shot Card Use, NIS Q2/2007

	Used a shot card	Did not use a shot card	Overall
Listed households	1.5	2.1	1.9
Unlisted households	1.8	2.3	2.2
Overall	1.5	2.2	

Source: CDC, NCRID and NCHS (2008), 2007 National Immunization Survey.

4. Discussion

This paper continues the research on comparing listed and unlisted households. Consistent with literature on listed households, we found significantly higher screener and interview completion rates among listed households than the unlisted households. In addition, our analyses showed the potential of field cost savings with listed households; the

average number of call attempts to obtain a completed interview was significantly lower for listed households than for unlisted households and the listed telephone numbers had substantially higher working residential numbers (64%) than the unlisted telephone numbers (6%). These findings suggest that oversampling listed telephone numbers could potentially boost response rates of a telephone survey through higher screener and main interview completion rates while reducing costs of data collection in terms of the number of call attempts needed to complete an interview.

We extended the research on comparing listed and unlisted households by examining their response behaviors and response quality. No significant differences were observed in the rates of shot card use, consent rates, or percentage of children with provider-reported vaccination data by listed status of the household telephone numbers. However, when we compared household response on vaccinations to provider reported data, listed households seemed to give less inconsistent responses than unlisted households whether or not a shot card was used during the interview.

The screener completion and main interview completion rates are higher for listed households than unlisted households. In addition, listed households tended to have fewer inconsistent responses on their children's vaccine receipt status. However, we caution the readers about the limitations of this study. First, we only examined differences by listed status of households. We need to examine whether or not these differences are caused by compositional differences of the two groups. In other words, we have yet to control differences between the two types of households on household-level characteristics, the responding person's demographic characteristics, and ecological characteristics (such as exchange-level information) to tease out any potential confounding effects. Second, this paper focuses on how listed households differ from unlisted ones in their propensity to respond to survey requests and in their response behaviors. We did not study their differences in vaccination estimates. Results from this analysis brings some reassurance to survey practitioners who are thinking of oversampling listed telephone numbers to reduce survey cost and increase participation. However, more research is still needed to make informed survey design decisions on whether and how to take advantage of listed telephone numbers to improve survey estimates.

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Appendix. Questions Used in Calculating Item Nonresponse Rate

Question names are listed in the table. For question wording, please refer to the 2007 Data User Guide on the NIS web page (ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NIS/NISPUF07_DUG.pdf)

	For household respondents who used a shot card	For household respondents who did not use a shot card
1	AN1	B2
2	AN2	B3
3	AN3	B4
4	AN4	B5
5	AN5	B6
6	AN6	B6_B
7	AN8	B8
8	CWIC_01	
9	CBF_01	
10	CBF_N	
11	C1	
12	C1_A	
13	C2_06Q3	
14	C5	
15	CFAMINC	
16	C20_06Q3	
17	C21_06Q3	
18	CNOSERV	
19	INS_1	
20	INS_3	
21	INS_4	
22	INS_5	
23	INS_6	
24	INS_14	