BIAS FROM EXCLUDING HOUSEHOLDS WITHOUT TELEPHONES IN RANDOM DIGIT DIALING SURVEYS: RESULTS OF TWO SURVEYS

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Key Words: Sample Design, Community Tracking Survey, National Survey of America's Families

1. Introduction

This paper compares estimates of a variety of characteristics for households with and without telephones, and also compares estimates based on all households to those based on only those with telephones. A large number of surveys are conducted using Random Digit Dialing (RDD) and restricted to only households with telephones. This is a relatively low cost per unit method of interviewing, but there is usually some concern about the bias in survey estimates due to the exclusion of households without telephones. In some surveys, such as the two in this paper, the concern is so great that a pure RDD survey is rejected. This paper should be useful for planners of future surveys in deciding whether the bias caused by leaving out households without telephones is sufficiently small that an RDD survey should be conducted.

The "classic" paper comparing households with and without telephones is Thornberry and Massey (1988) using data from the National Health Interview Survey (NHIS) on a number of demographic and health characteristics. For many characteristics, there were large differences between households with and without telephones.

More recently, Giesbrecht et al. (1996) provided data on a variety of characteristics obtained from the Current Population Survey (CPS). There were large differences between households with and without telephones for nearly every characteristic examined. Also, Fox and Riley (1996) used data from the 1990 Census and American Housing Survey (AHS), on gross rents and the extent of physical problems in rental units. The authors found that there was little bias as the result of excluding households without telephones.

This paper utilizes data from two surveys; the Community Tracking Survey (CTS), and the National Survey of America's Families (NSAF). Each survey had an RDD component for households with telephones and an area probability sample for households without telephones.

Our approach for this paper is to compare estimates made for the entire sample to those that would be obtained using only the households in the RDD component. The tables also present separate estimates for the field component. Where the estimates differ, there is a possibility that the RDD sample has non-zero bias. While the field sample represents only about 5 percent of the target population, earlier research indicated some large differences between the field and RDD samples. Thus, omitting the field component could result in biased estimates, even if the biases are not likely to be large.

An important consideration is how to interpret any noted differences. Criteria that we employed include: statistical significance, the size of the difference relative to policy considerations, and the size of the difference relative to other sources of error. Whether a difference is large enough to be relevant for policy-making purposes is subjective. We consider the size of the bias relative to the estimate and how the bias translates into other units, such as persons affected or dollars spent. Certainly a bias that is substantial relative to the estimate itself would be considered important. However, a small relative bias can still be important. Bias of plus or minus a percentage point may seem small, and may comprise a relative bias of 2 percent or less, but may represent millions of persons.[1] In terms of relative precision, a bias that is half as large as the standard error of a sample estimate would increase its Mean Square Error (MSE) by 25 percent[2], and a bias as large as the standard error would double the MSE. To the extent that users of data rely on the precision of the estimates as an indicator of accuracy, an unreported bias the size of at least half a standard error could be misleading. This of course assumes that the only source of survey bias is the exclusion of households without telephones. If this bias is in fact additive to other biases, then the total contribution of the bias to the MSE would be greater.

2. The Community Tracking Survey

The CTS collected data on health care utilization, experiences with the health care system, and health insurance coverage. Interviewing for the CTS was conducted by Mathematica Policy Research for the Center for Studying Health Systems Change (CSHSC); the study is funded by the Robert Wood Johnson Foundation. Data were collected between August, 1996 and July 1997.

The CTS collected data from 26,277 households sampled using random-digit-dialing methodology (the RDD component). In addition, 453 households (the

[1] Differences of around 2 percentage points between CTS and the CPS estimates of the percentage of persons that had no health insurance was troubling enough that the Center for Studying Health Systems Change commissioned a study to explore the reasons for the difference (Rosenbach and Lewis, 1998).

[2] Where the MSE = Variance + Bias^2

field component) were contacted by a personal visit from a lister/screener and interviewed by having the respondent use a cellular telephone (carried by the lister/screener) to call a central telephone interviewing facility. All households in the field component reported a recent interruption in telephone service. For this paper we will compare data from the households in the field component to data from 21,115 households in the RDD component that represent the same strata in the study population.

The bulk (90 per cent) of the RDD component interviews were conducted in 60 sites, which were selected with probability proportional to size (PPS) and comprise a national multi-stage sample. Twelve sites (the high-intensity sites) were randomly selected from the 48 sites comprised of MSAs that in 1992 had a population of at least 200,000 persons. The high intensity sites each have larger allocation of sample (an average of 965 households) than others sites. RDD interviews were also conducted as part of a stratified random sample of telephone households designed to supplement the 60 site sample and increase the precision of national estimates.

All field component interviews were conducted in the 12 high intensity sites, among listing/interviewing areas (IAS) selected with PPS from an area probability frame. The design excluded block groups with very low estimated prevalence of households without telephones. Only households that reported an interruption of at least two weeks between the beginning of the field period and the time of screening were included in the sample. The screening survey also asked for presence of a working telephone at the time of screening. Responses to the interruption question correlated highly, but not perfectly with presence of a working telephone at the time of screening: 95 percent of those with no working telephone on the day of screening were eligible, compared to four percent of others. More details about the design can be found in Metcalf, et al. (1996), Hall (1998) and Strouse, et al. (1998).

2.1 Analysis of CTS Data

The data used in this analysis are restricted to the strata (48 sites) that represent MSAs with 1992 population of 200,000 or more. The reason for this restriction is that the field component was conducted only in these strata[3]. The analysis was conducted with SUDAAN software, using weights constructed to produce national estimates. The weights for both components took into account the presence of multiple telephones and the length of any reported interruption in telephone service (see Strouse et al., 1998, for a discussion of the weighting procedures). The analysis took account of the multistage nature of the CTS design.

The variables in the present analysis include measures of health care utilization, cigarette smoking, and health insurance coverage status. Data are presented separately for adults and children.

To determine statistical significance (we chose the traditional cut-off of $p <= 0.05$) we tested for differences between the field and RDD components[4]. For categorical variables, we used the chi-square statistic described in Shah, Barnwell and Bieler (1996, p. 6-18). For continuous variables we used the t statistic.

Table 1 shows the results of our analysis. Section A of Table 1 presents categorical variables estimated for adults. Of the 9 variables, differences between the RDD and the whole sample were statistically significant for 8; for 7 of these, the absolute value of the estimated bias was at least half as large as the estimated standard error for the RDD sample. Of these 7 variables, two also have an estimated bias of over a percentage point and given their nature (smoking and health insurance coverage), a bias of this magnitude might be of interest to those concerned with health policy issues. The difference of 1.71 percentage points for those who still smoke (as a percent of those who have ever smoked), while only 3 percent of the RDD estimate, represents approximately 1.1 million adults. In the area of health insurance coverage, the RDD sample produced a lower estimate (by 1.54 percentage points) of those without health insurance. As noted above each percentage point represents about 1.2 million adults in this age group.

Table 1 (Section B) presents data for 6 categorical variables estimated for children. Statistically significant differences with estimated bias of at least half the RDD standard error were detected for 5 of the 6. As was the case for adults, the potential bias is largest in measures of health insurance coverage. These figures indicate the RDD sample alone would have underestimated the percent on Medicaid and overestimated the percent of children with private health insurance through a job, by approximately 2 percentage points.

Results for the selected continuous variables are presented in Section C of Table 1. Of the 4 estimates we find significant differences for 2. For each of these the estimated bias is at least half the size of the RDD standard error.

It appears that omitting the field component from the CTS survey would have resulted in some bias in sample estimates. While the RDD households with

[3] In other strata (comprising 12 sites), the CTS weights relied on data on telephone service interruption to weight the RDD component to represent all households with interruptions in service, including those that would have had a chance of inclusion only in the field component.

[4] Since the two components are mutually exclusive, finding a statistically significant difference between them means that the difference between either component and the whole is also significantly different than zero.

telephone service interruptions had higher weights than those with none, it is possible that the biases noted above could have been reduced to unimportant levels by giving even more weight to such households in the RDD sample. We adopted this approach for sites in smaller MSAs and non-metropolitan areas. As noted in Hall (1998), CTS RDD households with service interruptions resemble field component households more than they do the remainder of the RDD sample. However, the cost of such a strategy would be increased loss of precision due to differential weighting.

A few of the biases noted above are large enough that they should be considered important. The CTS has a very large sample, and for many estimates it has high levels of precision, despite the relatively high degree of clustering in the sample design. Thus even moderate sample related biases could make statements about precision (standard errors, confidence intervals) misleading in terms of assessing the accuracy of sample estimates.

3. The National Survey of America's Families

The NSAF collected information on the economic, health, and social dimensions of the well-being of children, adults under the age of 65, and their families in 13 states, Milwaukee, and the balance of the nation. The NSAF is a household survey that is part of the Urban Institute's Assessing the New Federalism project, which receives funding through a consortium of private foundations.[5] The details on the sample design features are given in Brick, P.D. et al. (1999) and Judkins et al. (1999).

As in the CTS, the components of the survey were a RDD survey of households with telephones, and an area sample conducted in person for those households without telephones. This dual-frame approach is further described in Waksberg, et al. (1997). The data collection for the RDD sample was conducted form February to November 1997 for samples drawn within each study area. A list-assisted RDD sample method was used to select the sample of telephone households separately for each study area.

The area sample was selected in two stages. The first stage was the PPS selection of Primary Sampling Units (PSUs) defined by groups of counties with similar characteristics (whether a metropolitan statistical area and by the poverty rate). In the frame, areas with high telephone rates were excluded. In the second stage, segments were selected and subsampled. During the creation of the segments, households in Block Groups (BG) with high telephone coverage rates above a predetermined cut off point were excluded. The weighting procedure included adjustments to account for this exclusion. In the area sample, households saying they did not have telephones were interviewed by cellular phone from a centralized Westat telephone center rather than by the interviewer who visited. (Cunningham, P., et al. 1999).

In NSAF, weights were constructed to produce estimates at the study area and national levels. The weights used both components and took into account the presence of multiple telephones (see Brick, J.M. et al. 1999, for a discussion of the weighting procedures). An additional weight that only used the RDD component of the survey was created following the same weighting procedure applied to the regular NSAF weight.

Measures of income, program participation, insurance coverage, and economic hardship are included from the 1997 NSAF for both children and non-elderly adults. Measures of family structure, participation in different types of activities, and engagement in school were also examined for children while employment was examined for adults. See Dipko, S. et al. (1999) for details.

3.1 Analysis of NSAF Data

Table 2 reports estimates on a range of different characteristics from the total, RDD and field samples for adults and children. What is striking is the income differential between telephone and nontelephone households. Non-elderly adults living in households without telephones are 4.44 times more likely than those living in households with telephones to have family incomes below the Federal Poverty Level (FPL). Fully 86 percent of non-elderly adults without telephones live in low-income families (defined as below 200 percent of the FPL) compared to 28 percent of adults with telephones.

Thus, income statistics are sensitive to the inclusion of the area sample. A poverty rate of 11.13 percent is estimated for the RDD sample whereas a poverty rate of 12.35 percent is estimated for the combined sample -- an absolute difference of 1.22 percentage points and an understatement of the poverty rate of about 10 percent. The proportion of adults living in low-income families is underestimated by 1.35 percentage points or 4.6 percent. These findings indicate that because households without telephones have much lower incomes than households with telephones, estimates of poverty rates drawn exclusively from an RDD sample will be biased downward.

Of the eight additional measures included for non-elderly adults, seven of the differences between the RDD and the whole sample were statistically significant. For these seven measures, the absolute value of the estimated bias was three to four times as high as the estimated standard error for the RDD sample. The only exception was the employment measure where the percentages working full or part-time in the RDD and combined samples were almost identical -- 84.13 percent vs. 84.20 percent.

[5] The private foundations include the Annie E. Casey Foundation, the Henry J. Kaiser Foundation, the W.K. Kellogg Foundation, the John D. and Catherine T. MacArthur Foundation, the Commonwealth Fund, the Fund for New Jersey and the Robert Wood Johnson Foundation.

Across the measures included, the magnitude of the estimated differences between the RDD and the whole sample is largest for the two income measures. For measures such as receipt of food stamps and AFDC (now called TANF), which are highly correlated with income, the bias is small in absolute terms, but large in relative terms. For example, the RDD sample understates the receipt of food stamps and AFDC among adults by 1.07 and .48 percentage points respectively which translates into 12.26 percent -- or two million -- fewer adults on food stamps and 14.41 percent -- or one half of a million -- fewer adults on AFDC. Relative differences of this magnitude may well be relevant from a policy perspective.

Similar to adults, children living in households without telephones are concentrated at the lower end of the income distribution (Table 2). Almost 70 percent of all children without telephones live below the poverty line and 94 percent live in families with low-incomes, compared to 18 and 40 percent, respectively of children in households with telephones. The RDD sample understates the poverty rate for children by 2.63 percentage points -- an understatement of almost 13 percent. The proportion of children in families with low-incomes is underestimated by 2.31 percentage points -- a 5.41 percent underestimate.

Of the 14 additional measures included for children, 12 of the differences between the RDD and the whole sample were statistically significant. For the AFDC, Food Stamp, and Medicaid measures, the absolute value of the estimated bias was 4 to 5 times as great as the estimated standard error for the RDD sample; for the food security items, the uninsured rate, the proportion living with a single parent, trouble paying bills, and involvement in extracurricular activities, the ratio was between 1.56 and 3.02, while for the school engagement, outings, and reading questions, the ratio was one or less.

Measures that are more closely tied to income -- such as receipt of food stamps, AFDC, and Medicaid tend to have larger biases when estimated exclusively from an RDD sample compared to measures that are less correlated with income such as how often the families read to their children or how highly engaged the child is in school. The RDD sample understates the proportion of children receiving AFDC, food stamps, and Medicaid by between 12.49 and 16.46 percent. In contrast, the RDD sample overstates the proportion of children who are involved in extracurricular activities, who are highly engaged in school, who have at least one outing per day, and who are read or told stories to 6 or more days a week by a much lower percent (by less than 5 percent).

Because the percentage of households with telephones rises sharply with income, we also examined the patterns of differences between the RDD and the whole sample for adults and children in different income groups. This analysis suggests that differences between the RDD and the whole sample are not only due to income differences between telephone and non-telephone households but also appear to result from differences between non-telephone and telephone households within an income group. Controlling for income, adults and children in non-telephone households tend to be worse off than adults in telephone households; they are more likely to have cut back on or skipped meals and to report difficulties paying rent, mortgage or utilities, less likely to never worry about food, and more likely to be uninsured. Differences between the estimates for the RDD and the whole sample tend to be greatest for the lower income categories -- i.e., with incomes below 50 or 100 percent of the federal poverty level and lowest in higher income categories above 200 percent of the federal poverty level. For example, the estimated differences between the food stamp participation rates for the RDD and the whole sample were 5.67 and 3.32 percentage points for adults with incomes below 50 percent of the FPL and between 50 and 100 percent of the FPL respectively while differences of .05 and .01 were found for adults with incomes between 200 and 300 percent of the FPL and above 300 percent of the FPL respectively. Thus, RDD estimates tend to be more biased for the low-income population than for the whole population. As a consequence, they also tend to understate differences between high and low-income groups.

4. Conclusions

Exclusive reliance on an RDD sample will result in bias for nearly all the characteristics examined for CTS and NSAF, two large scale surveys. The size of the bias can be substantial in policy terms, for example, the RDD sample from the NSAF estimates 1.5 million fewer children in poverty than the combined sample. Measures that are less correlated with income, such as the degree to which children are highly engaged in school, tend to have lower absolute and relative biases than those that are more closely tied to income such as receipt of means-tested benefits. The bias is large relative to the standard error for most of the characteristics, including some characteristics (such as read stories 6 days per week) not closely tied to income. Of course, for a survey with a small sample size or if considering small demographic groups, the bias will be much smaller relative to the standard error.

In addition, the NSAF and CTS analyses are national in scope. Given the large variability in the share of households lacking telephones across states, the likely size of the bias due to omitting non-telephone households from the sample frame will also vary across states. For example, these results will tend to understate the bias that would result from RDD surveys in states or local areas in which more households lack telephones compared to the national average and overstate likely biases in other states and areas.

Ultimately, a survey planner can only use the results of this paper and earlier papers with

comparisons between telephone and non-telephone households as a starting point for decisions. The sample size, survey budget, cost of field work, and political sensitivity of a survey are all factors in a decision.

One promising approach is to use Keeter-type weighting adjustments, in which RDD households with recent interruptions in telephone service are given larger weights to compensate for the exclusion from the sample of non-telephone households. Brick et al. (in press) and Hall (1998) indicate that this approach is effective in reducing bias. Given the high relative cost of non-telephone interviews and the generally moderately large biases for RDD estimates, Keeter-type adjustment might be the best alternative for many surveys. Given the close relationship between income and telephone status, poststratification for income classes can also be effective in reducing RDD biases.

Table 1. Comparison of RDD and field estimates for CTS

Variable	Total		RDD		Field		Bias
A. Adult Characteristics	%	SE	%	SE	%	SE	%
Any Doctor Visits[1]*	75.36	0.75	76.21	0.68	54.60	3.32	0.85[b]
Had Flu Shot[1]*	25.21	0.79	25.71	0.81	12.67	1.42	0.50[a]
Any Overnight Hospital Stays[1]	3.03	0.1	3.00	0.1	3.97	0.84	-0.03
Ever Had Mammogram[2]*	84.04	0.53	84.66	0.43	48.45	6.91	0.62[b]
Any Surgical Procedures[1]*	14.48	0.35	14.65	0.35	10.28	1.29	0.17
Has Usual Source of Care*	85.64	0.71	86.13	0.64	72.93	3.18	0.49[a]
Smoke Now[3]*	52.09	0.59	50.38	0.48	85.42	2.38	-1.71[b]
Covered by Medicaid[4]*	4.21	0.28	3.58	0.18	17.9	3.13	-0.63[b]
Uninsured[4]*	17.05	1.07	15.51	1.02	50.46	3.67	-1.54[b]
B. Child Characteristics	%	SE	%	SE	%	SE	Bias
Any Doctor Visits[1]*	82.12	0.84	82.66	0.77	72.8	3.4	0.54[a]
Any Overnight Hospital Stays[1]*	0.77	0.1	0.74	0.1	1.30	0.84	-0.03
Any Surgical Procedures[1]*	6.71	0.32	6.98	0.34	2.15	1.1	0.27[a]
Has Usual Source of Care	94.44	0.62	94.71	0.43	89.87	4.31	0.27[a]
Covered by Medicaid*	14.65	1.05	12.65	0.67	49.24	6.03	-2.00[b]
Uninsured*	11.54	0.81	11.03	0.71	20.24	4.28	-0.51[a]
C. Continuous Variables	Mean	SE	Mean	SE	Mean	SE	Bias
Number of Doctor Visits, Adults*	3.98	0.06	4.02	0.05	3.05	0.04	0.04[a]
Number of Doctor Visits, Children	3.38	0.06	3.38	0.06	3.36	0.42	0.00
Travel Time (minutes) to Last Doctor Visit, Adults*	18.70	0.14	18.55	0.13	24.12	1.54	-0.15[b]
Travel Time (minutes) to Last Doctor Visit, Children	16.89	0.32	16.84	0.25	17.87	2.27	-0.05

[1]In 12 months prior to interview.
[2]Women age 45+.
[3]Among adults who reported ever smoking.
[4]Adults 18-64.
[a]Absolute value of estimated bias > 0.50 standard error of RDD.
[b]Absolute value of estimated bias > 1.00 of RDD.
*p value for Chi-square statistic < .05.

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Table 2. Comparison of RDD and field estimates for NSAF

Variable	Total		RDD		Field		Bias
	%	SE	%	SE	%	SE	%
A. Adults							
Family under 100 percent poverty level	12.35	0.25	11.13	0.23	54.72	2.88	-1.22*
Family under 200 percent poverty level	29.02	0.35	27.67	0.35	86.08	1.9	-1.35*
Family currently receives food stamps	8.49	0.25	7.42	0.23	45.60	3.71	-1.07*
Family receives AFDC	3.33	0.16	2.85	0.14	19.57	2.23	-0.48*
Adults sometimes cut or skip meal for lack of money[1]	10.73	0.31	9.88	0.27	37.86	3.45	-0.85*
Never worries about food running out[1]	80.59	0.36	81.77	0.33	37.03	3.08	1.18*
Unable to pay mortgage, rent or utilities bills[1]	11.39	0.24	10.55	0.23	38.94	2.21	-0.84*
Currently works full-time or part-time	84.20	0.29	84.13	0.29	83.39	1.54	-0.06
Currently without health insurance	16.81	0.33	15.86	0.30	53.48	2.14	-0.95*
Currently has Medicaid coverage	4.10	0.16	3.65	0.14	19.96	2.18	-0.44*
B. Children							
Family under 100 percent poverty level	20.40	0.55	17.77	0.44	69.61	4.6	-2.63*
Family under 200 percent poverty level	42.65	0.54	40.34	0.57	93.71	1.59	-2.31*
Family currently receives food stamps	19.01	0.62	16.32	0.42	69.55	4.74	-2.70*
Family currently receives AFDC	11.22	0.47	9.37	0.32	45.26	4.49	-1.85*
Family sometimes cut or skip meals for lack of money[1]	14.54	0.49	13.57	0.43	33.83	3.80	-0.96*
Never worries about food running out[1]	72.15	0.57	74.07	0.50	34.07	4.27	1.92*
Currently without health insurance	11.90	0.35	11.31	0.31	24.47	2.63	-0.58*
Currently has Medicaid coverage	17.77	0.42	15.56	0.36	59.46	3.75	-2.22*
Unable to pay mortgage, rent or utility bills[1]	18.18	0.53	16.83	0.45	42.93	4.39	-1.35*
Involved in at least one extra curricular activity[2]	83.17	0.47	84.06	0.47	62.64	4.12	0.89*
Highly engaged in school[2]	40.97	0.76	41.35	0.78	30.00	3.87	0.38
Has one or more outings per day[3]	24.60	0.87	25.03	0.82	17.24	3.69	0.43
Read or told stories six or more days per week[3]	47.66	1.01	48.70	1.04	30.40	4.01	1.04*
Lives with single parent	26.93	0.52	26.10	0.48	50.01	4.44	-0.83*

*Statistically significant at the .05 level.
[1]Reference period in the twelve month period proceeding the time of the survey.
[2]Petrains to children aged 6 to 17.
[3]Pertains to children under age 6.