Dual Frame Telephone Sampling for a National Survey with State Estimates

Kristie Healey[1], Ronaldo Iachan[2], Naomi Freedner[1], Joshua Brown[1], Kisha Bailly[3]

[1]ICF International, 126 College Street, Burlington, VT 05401

[2]ICF International, 530 Gaither Road, Suite 500, Rockville, MD 20850

[3]ICF International, 354 7th Ave S, Fargo, ND 58103,

Abstract

This paper presents a dynamic dual-frame sampling approach for a national survey that selects monthly samples independently for each of the 50 US states and the District of Columbia. The survey excludes the overlap set of cell numbers that also have landline access. The design also oversamples listed households in the landline sample, and a subset of cell numbers flagged as active via Marketing Systems Group's Cell-WINS service. We examine gains on productivity resulting from the oversampling in both frames.

Introduction

RDD landline studies have long been an effective method of reaching the general US Population. A study by Casaday and Lepowski (1993) estimated that over 95 percent of the US household population was covered by a list assisted RDD sample consisting of 100-blocks containing at least one listed number.

In the last two decades the coverage of the landline frame has changed. The percent of households reachable only by cell phone has increased to 41 percent as of the second half of 2013 (Blumberg and Luke, 2014). Many surveys now sample both landlines and cell phones in order to reach the cell-only population. Furthermore, telephone companies are changing the way landline telephone numbers are assigned. An increasing number of landline households are served by Competitive Local Exchange Carriers (CLECs) and voice over Internet Protocol (VoIP) providers (Fahimi et al. 2009). Landlines served by these nontraditional providers are often either delayed to report to listing directories or remain unlisted entirely. Sample vendors have considered adaptations to these changes including using 1+ 1000-series blocks and supplementing with POTS exchanges containing residential assignments (Fahimi and Brick, 2008). However, these come at the price of including more unassigned numbers in the frame.

In RDD studies where large numbers of interviews are conducted, small changes in costs per completed interview can have large impacts on the overall budget. Data collection costs can be minimized by eliminating telephone numbers that are less likely to be productive. In 2002, Brick et al. described a two-phase list-assisted methodology to increase the efficiency of landline telephone samples. Phase one selects an initial simple random sample from the sampling frame, matching the sample to White Pages directories as well as databases of mailing addresses, and subsampling in differential rates by either listed status or the presence of a mailable address. Both oversampling methods produced gains inefficiencies, with oversampling by mailable status performing somewhat better. The Centers for Disease Control (CDC) has used a smilar oversampling strategy in RDD studies such as the Behavioral Risk Factor Surveillance System, which has oversampled listed numbers since 2003.

New technology allows for the flagging of cell phone numbers with recent activity status. This provides an opportunity for a similar oversampling strategy within cell phone frames. Since cell sample must be manually dialed in accordance with FCC regulations an oversampling strategy which increases the proportion of cell phones flagged as active could result in substantial savings. Dutwin and Malarek (2013) estimate that cell phone numbers flagged as inactive or unknown can be eliminated from sample selection with a noncoverage bias of only 0.2 percent.

This paper examines the continued relevance of the dual-phase strategy of oversampling listed telephone numbers in a landline RDD frame. It also evaluates potential gains in dialing efficiency using a similar plan to oversample cell phone numbers that have been prescreened as active.

Methods

In October of 2013 we began fielding a dual-frame RDD survey to measure the smoking and related behaviors of adult US residents. A total of 75,000 interviews are expected to be completed by the conclusion of data collection in October 2014. The sample is stratified by state to produce estimates at the state level while keeping design effects low for national estimates. Within each state 70% of interviews are conducted by landline, and 30% with cell respondents who identify themselves as cell-only.

Telephone numbers were drawn on a monthly basis to obtain an approximately equal number of interviews per month. The desired sample size N was determined based on the monthly target of interviews and a historic estimate of the number of attempted phone numbers required per completed interview. A first stage sample was drawn of size

$$\frac{NS}{Sp + 1 - p}$$

where S is the oversampling rate, and p is the proportion of the sampling frame estimated to be listed or active. Landline and cell phone records were delivered to the sample vendor, to be matched to mailing addresses and activity flag respectively. In the second stage of sampling, all listed or active records were selected, as well as a portion of the unlisted or inactive records equal to one over the oversampling rate.

The working oversampling rates were 1.5 for landline and 3.6 for cell. The landline sampling plan was based on that of the Behavioral Risk Factor Surveillance System

(BRFSS), which oversamples listed telephone numbers at 1.5:1 relative to unlisted numbers. However, there was little precedence for oversampling active numbers within cell surveys. The oversampling ratio of 3.6 was determined by optimal cost/variance allocation based on a study by Peters, et al. (2014).

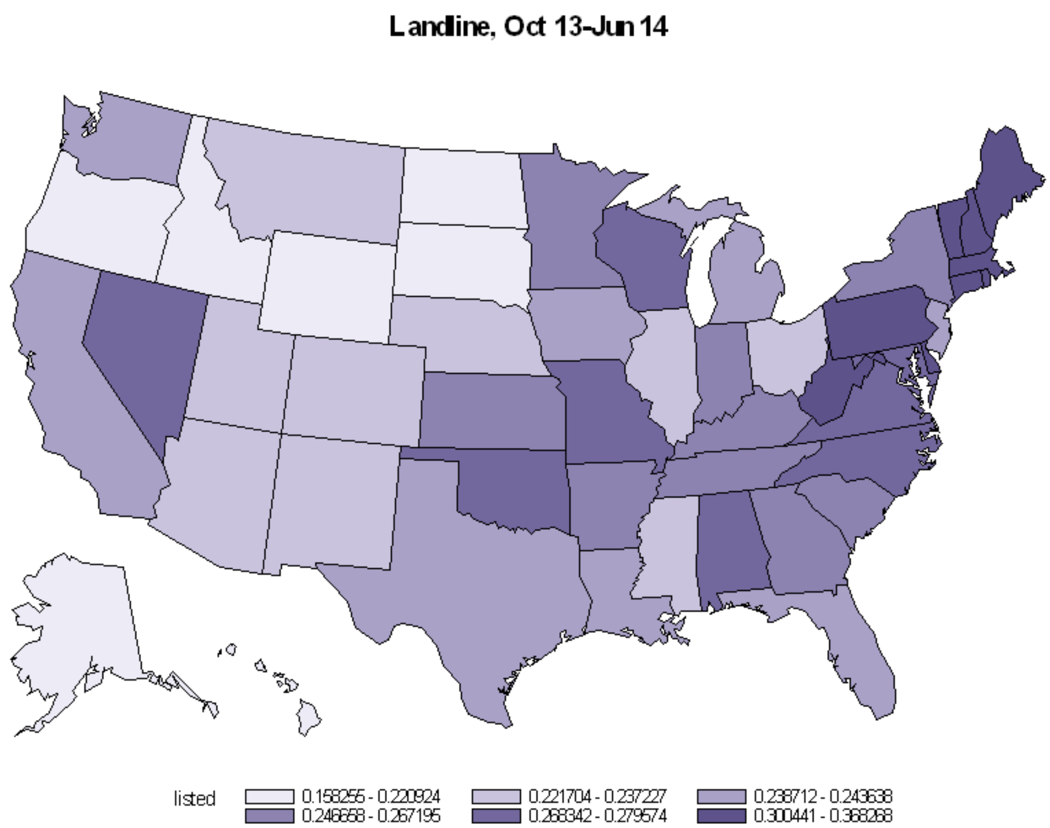
Landline records were dialed according to a 15-attempt protocol with a minimum of three weekday daytime attempts, three weekday evening attempts, and three weekend attempts. Records that were successfully matched to a complete address were mailed a prenotification letter a few days before fielding began.

Cell records were dialed according to a six-attempt protocol, with a minimum of two weekday daytime attempts, two weekday evening attempts, and two weekend attempts. A record was determined to be eligible if the potential respondent was at least 18 years old and living in a private residence with no landline present.

Landline Findings

Listed rates for landline telephone numbers vary by state. Prior to fielding, expected rates of listed landline telephone numbers ranged from 11.1 percent to 32.1 percent. Through the first nine months of data collections an average of 85,000 landline telephone numbers per month were dialed. Figure 1 illustrates the observed cumulative listed rates by state.

Figure 1: Landline listed rates by state



Tables 1 and 2 summarize the differences in final dispositions by listed status. Table 1 shows a sharp contrast in the percentage of nonworking telephone numbers by listed status. Table 2 displays dispositions as observed (unweighted) and a representation (weighted) of the distribution that would have been achieved without oversampling listed numbers. By oversampling listed numbers the overall sample contained approximately 5% fewer nonworking phone numbers than a sample of the same size without oversampling. This resulted in savings of approximately 28.5 interview hours that would have otherwise been needed to identify and disposition the excluded phone numbers.

Table 1: Final landline dispositions by listed status.

Category	**Listed (Pct)**	**Unlisted (Pct)**
Complete (Full and Partial)	34,253 (13.6%)	4,220 (0.8%)
Eligible Non-Interview	19,741 (7.7%)	3,295 (0.6%)
Unknown Eligibility	190.852 (49.3%)	67,074 (13.1%)
Ineligible, Nonworking	**59,065 (23.5%)**	**379,778 (73.9%)**
Ineligible, Other	14,750 (5.9%)	59,572 (11.6%)

Table 2: Comparison of weighted and unweighted dispositions.

Category	**Total N**	**Unweighted Percent**	**Weighted Percent**
Complete (Full and Partial)	38,473	5.0%	4.0%
Eligible Non-Interview	22,766	3.0%	2.4%
Unknown Eligibility	190,852	24.9%	22.0%
Ineligible, Nonworking	**438,843**	**57.3%**	**61.5%**
Ineligible, Other	74,322	9.7%	10.2%

Table 3 shows the differences in demographic distributions by listed status. Respondents from unlisted phone numbers were younger, more likely to be a minority, and more likely to be a current smoker than respondents with listed phone numbers. Although respondents from unlisted phone numbers were more likely to have a cell phone than respondents from listed phone numbers, unlisted respondents with cell phones used their cell phones more often than respondents with listed numbers. These demographic differences suggest that eliminating unlisted phone numbers entirely could result in non-coverage bias.

Table 3: Demographics by listed status.

Demographic	Listed	Unlisted
Mean age*	61.3	55.1
Percent male	39.6	40.0
Percent minority*	16.1	33.2
Current Smoker*	10.0	13.8
Percent with cell Phone*	83.6	81.7
Mean % calls on cell phone*	40.6	51.1

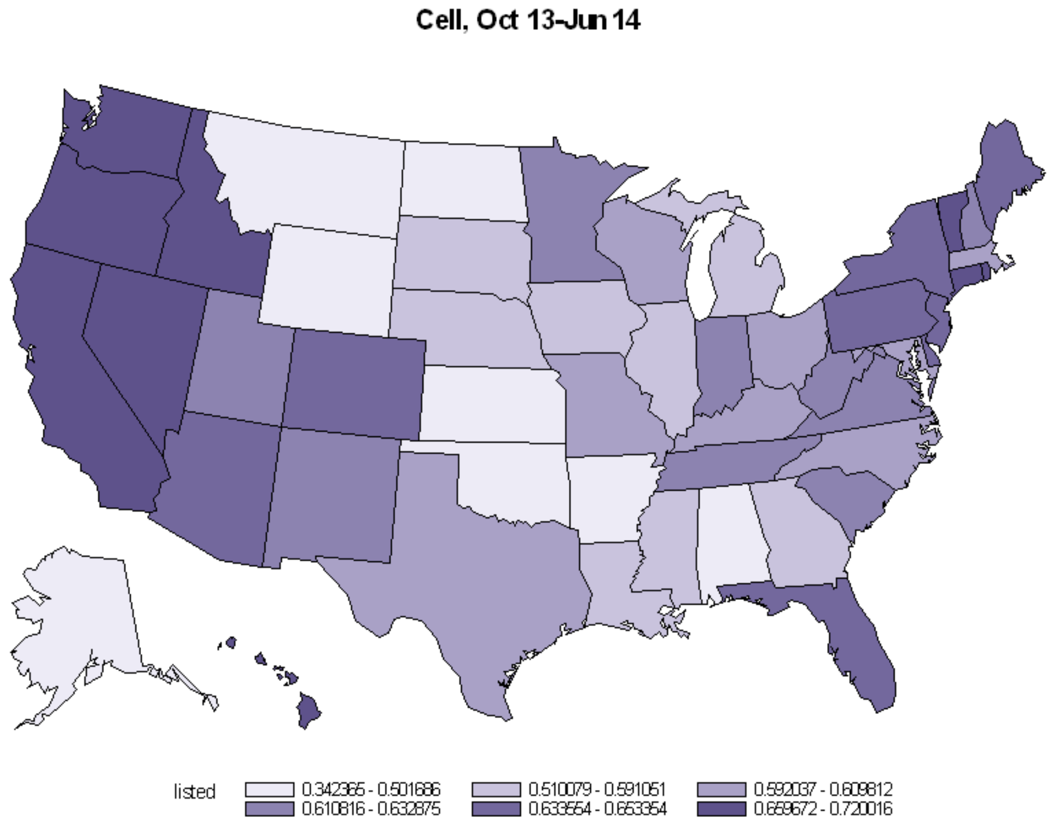
*Significant (P<0.05)

Among all landline respondents, 10.2 percent were estimated to be current smokers, defined as having smoked at least 100 cigarettes in their lifetime and currently smoking every day or some days. This prevalence was computed after weighting the data to adjust for disproportionate sampling, including the oversampling of listed telephone numbers. The standard error was 0.2 percent, resulting in a design effect of 1.24.

Cell Phone Findings

Prior to fielding, 60 percent of cell phone numbers were estimated to be active. An average of 50,640 cell phone records were dialed per month through the first nine months of fielding. Observed activity rates varied by state, as shown in Figure 2.

Figure 2: Cell phone activity rates by state



There were large differences in the distributions of final dispositions by activity status. Less than four percent of cell phone numbers flagged as active were proven to be nonworking, compared to nearly two thirds of cell phone numbers flagged as inactive or unknown. Table 4 displays the distributions of final dispositions in more detail.

Table 4: Final cell phone dispositions by activity status.

Category	**Active (Pct)**	**Inactive/Unknown (Pct)**
Complete (Full and Partial)	16,121 (4.2%)	239 (0.3%)
Eligible Non-Interview	12,636 (3.3%)	440 (0.6%)
Unknown Eligibility	296,779 (77.1%)	23,062 (33.4%)
Ineligible, Nonworking	**14,259(3.7%)**	**44,422 (64.3%)**
Ineligible, Other	45,274 (11.8%)	908 (1.3%)

Table 5 displays the distributions of dispositions as observed as well as weighted to represent the expected distribution without oversampling. The oversampling plan produced about 50 percent fewer nonworking numbers than a sample of the same size without oversampling active numbers. Cell phone numbers included in RDD surveys are prohibited by FCC regulations to be dialed using a predictive dialer. Thus, manual dialing results in more interviewer effort to disposition a nonworking cell number than a landline number. Oversampling active cell phone numbers saved an estimated 1,340 interviewer hours through nine months of fielding.

Table 5: Comparison of weighted and unweighted dispositions.

Category	N	Unweighted Percent	Weighted Percent
Complete (Full and Partial)	16,360	3.6%	2.7%
Eligible Non-Interview	13,076	2.9%	2.2%
Unknown Eligibility	319,841	70.4%	59.9%
Ineligible, Nonworking	**58,681**	**12.9%**	**27.5%**
Ineligible, Other	46,182	10.2%	7.7%

Table 6 displays the demographics by activity status. Similar to the landline differences, respondents reached on a cell phone flagged as inactive or unknown were more likely to be a minority or a current smoker than respondents reached on a cell phone flagged as active. There may be some risk of non-coverage bias by eliminating all inactive and unknown cell numbers from dialing. However, since less than 1.5 percent of all cell interviews came from inactive or unknown numbers, this risk is likely low.

Table 6: Demographics by activity flag.

Demographic	Active	Inactive/Unknown
Mean age	39.6	40.4
Percent male	52.8	53.5
Percent minority*	34.0	41.2
Current Smoker*	20.6	30.2

*Significant ($P<0.05$)

21.5 percent of all cell phone respondents were estimated to be current smokers, after weighting the data to adjust for disproportionate sampling. The standard error was 0.43 percent, resulting in a design effect of 1.24.

Discussion

Increased dialing efficiency was observed in both the landline and cell phone studies as a result of oversampling. The oversampling strategy does introduce some design effects, but they are small enough to justify the savings in data collection time. The cell study particularly benefitted from oversampling active records, and may benefit even further if phone numbers of inactive and unknown status are eliminated from dialing. Although there are demographic differences between cell interviews by activity status, the cell population with phone numbers flagged as inactive or unknown is small enough that there is little risk of non-coverage bias. Among landline interviews, over ten percent come from unlisted numbers, and there are significant differences in demographics by listed status. Eliminating unlisted landline numbers from dialing is not recommended.

Weighted estimates of current smokers were computed separately for landline and cell respondents, and weighted only by design weights. Upon completion of data collection we plan to re-evaluate the design effect after combining landline and cell data, using weights that have been post stratified to the demographics of the US adult population. Further research is recommended to identify whether 1.5 and 3.6 are still the optimal oversampling rates for landline and cell respectively. Geographic variations in listed and activity rates suggest that the optimal oversampling rates may vary by state.

References

Blumberg SJ, Luke JV. Wireless substitution: Early release of estimates from the National Health Interview Survey, July–December 2013. National Center for Health Statistics. July 2014. Available from: http://www.cdc.gov/nchs/nhis.htm.

Casady RJ, Lepowski JM. 1993. Stratified Telephone Survey Designs. *Survey Methodology 19:* 103-113.

Fahimi M, Kulp D, Malarek D. 2009. Topology of the Landline Telephone Sampling Frame. *Survey Practice 2*(9).

Fahimi M, Brick JM. 2008. Bias in List-Assisted 100-Series RDD Sampling. *Survey Practice, 1*(2).

Brick JM, Judkins D, Montaquila J, Morganstein D. 2002. Two-Phase List-Assisted RDD Sampling. Journal of Official Statistics, Vol. 18, No. 2, pp 203-215.

The BRFSS Data User Guide. August 15, 2003.
http://www.cdc.gov/brfss/data_documentation/PDF/UserguideJune2013.pdf

Dutwin D, Malarek D. 2014. Recent Activity Flags for Cellular Samples. *Survey Practice 7*(1).

Peters KR, Robb W, Delnevo C, Gundersen D. 2014. Strategies for Increasing Efficiency of Cellular Telephone Samples. Presentation at AAPOR 69th Annual Conference.