Addressing the Cell Phone-Only Problem: Cell Phone Sampling Versus Address Based Sampling

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Abstract

Developing cost effective methods for reaching households which no longer have a landline but do have access to a cell phone, so called cell phone only households (CPOs), is a critical item on the agenda of most data collection organizations. Concerns about sample coverage and data biases resulting from the exclusion of CPOs have increased over the past few years as the penetration of CPO households continues to climb, exceeding 50% in some subgroups. To date, two methodologies have emerged as potential means for addressing this issue. The first involves sampling telephone numbers from known cell phone exchanges and calling these numbers or combining these with a sample of landline numbers in a dual frame design. This approach can be further refined by either interviewing all of those who answer the cell phone regardless of whether they have a landline or screening cell phone respondents to identify those living in CPO households. An alternative approach involves sampling of addresses rather than telephone numbers. Address based sampling (ABS) is a new technique built upon the relatively recent availability of large scale address databases. For example, residential address data from the U.S. Postal Service provides nearly 98% coverage of U.S. households. Further, these addresses can be reverse-matched to commercially available databases to identify a relatively large proportion of telephone numbers, facilitating the use of mixed-mode approaches. Here we delineate and compare the advantages and limitations of these two approaches, including discussion of sampling and weighting approaches, operational considerations, timeliness, and cost. We draw examples from several recently conducted studies employing each of these approaches. The findings from this research help bring into sharper focus the potential alternatives to traditional random digit dialed (RDD) telephone surveys for conducting cost effective data collection of the general public.

1. Twilight for Landline Random Digit Dialing

For more than two decades, landline-based random digit dialing enjoyed preeminence among survey methodologies, facilitating high quality, quick turn-around, computer-assisted interviewing that met the needs of most researchers and clients. From the mid-1980s through the late 1990s, landline RDD was the workhorse methodology of the survey industry. Yet, with the dawn of the 21st century, issues which were first noted in the late 1990s became problems. First, the sheer number of telephone numbers increased with additional lines being added to the telecommunications system for businesses, faxes, modems, building security systems, and the like (Tucker, Lepkowski, & Piekarski, 2002). Although the number of residential telephone lines also increased, this increase has not kept pace with the overall increase in telephone lines, meaning that the percentage of telephone numbers that ring into residential households has decreased over time. As a result, the "hit rate" for residential numbers in telephone samples has gone down, increasing the cost and difficulty of identifying working household numbers

Next came the decline in response rates for landline RDD surveys Since the mid-1990s, the rate at which people agreed to participate in telephone surveys declined (Curtain, Presser, & Singer, 2005; Link, Mokdad, Kulp, & Hyon, 2006; Steeh et al, 2001). These drops in response rates of approximately 2-3 percent per year created concerns about the representativeness of the data collected using landline-based RDD methods. Several factors contributed to this decline, including the proliferation of call-screening devices, such as answering machines, Caller-ID, call-blocking, and call managers and a marked increase in the number of telemarketing calls households received as individuals often do not distinguish between a marketing sales call and a call for survey research (Oldendick & Link 1994; Link & Oldendick 2000; Link, Mokdad, Kulp, & Hyon, 2006).

Finally, the growth and popularity of cell phones has irrevocably altered the landscape of telephone survey research. By the end of 2006, nearly 70% of households had at least one working cell phone. Moreover, an increasing percentage of households have stopped using landline telephones, relying instead on their cell phone as their only telecommunication device. In the first quarter of 2008, an estimated 16% of US households were cell-phone only households, with the percentage being significantly higher for some groups, such as renters and younger adults (Blumberg and Luke, 2008). As a result, coverage of the landline telephone frame has decreased to pre-1970s levels. Added to this is the problem of number portability, whereby a household can "port" or permanently transfer their landline telephone number to their cell phone. This combined with the natural mobility of cell phones means that increasingly telephone numbers are no longer tied to a specific geography, which is a significant problem for samples targeting particular areas.

Researchers, data users, and clients who have come to depend on landline-based RDD find themselves at a crossroads. The problems with that methodology will not be fixed through the use of incentives, advance mailings, additional telephone calls, oversampling, or any of the many techniques designed to improve participation with this methodology. What is needed is a complete re-engineering or even re-imagining of how researchers need to go about the task of sampling to conduct cost-effective surveys of the general public. With the cost of face-to-face surveys being too high for many research efforts, recent research has pointed to two potential options for conducting relatively cost-effective, probability-based surveys: (1) combining cell phone exchanges with landline exchanges in a dual frame approach, or (2) dropping the dependence on telephones as the primary sampling unit and turning instead to sampling of addresses. We consider some of the major arguments for and against these two approaches in the sections below.

2. Dual Frame Sampling with Cell Phone Numbers

One potential solution is to sample from known banks of cell phone numbers, combining this sample with the landline sample in a dual frame approach (Brick et al 2006; Brick et al 2007; Link et al 2007; Kennedy 2007; Keeter et al 2008). The combination of the two frames should provide 90 to 95% coverage (the uncovered portion being the 2-3% with no telephones and the 2-5% of households in banks of numbers typically not sampled by survey researchers for efficiency sake, for instance, zero blocks). In addition to the improved coverage, the combined landline/cell phone sampling approach has a number of other potential benefits (see Table 1). First, it allows researchers to continue to use computer assisted telephone interviewing (CATI) as the primary vehicle for conducting telephone surveys. The survey industry has a substantial investment in CATI system infrastructure. The ability to continue to leverage this infrastructure is vital to the continued viability of many of these organizations, particularly smaller and mid-size data collection organizations for whom landline RDD is the sole or primary for of their work. With the continued use of CATI researchers are better able to administer complex questionnaires and conduct quick turn-around surveys. In terms of sample costs, the per unit cost for cell phone numbers is only slightly more than that of traditional landline per unit costs.

Unfortunately, sampling and contacting households by cell phone faces a number of challenges, some severe. First, from a sampling perspective, the frame of known cell phone numbers is a very inefficient one. That is, it contains a large, but unknown, number of cell phone numbers which are either not in service or in service but rarely used or answered. As a result, researchers must either make a large number of calls per case or sample a larger number of cell phones in order to reach an individual. Cell phones may also not be in use in the geographic area from which they were sampled. Typically the area code for a cell phone is based on the cell phone area code associated with the point of purchase or where service was activated. Because cell phones are mobile devices the phones may be activated in one location but used in another. Number portability laws are also making it easier for respondents to retain their numbers when moving from one location to another. As a result, a number thought to be located in Cincinnati may actually be used by a household in Atlanta (or in Seattle, which may be more problematic from an operational perspective due to differing time zones). Potentially more problematic, unlike the landline frame, the cell phone frame is rather barren in terms of additional information about the number, such as associated address, name, projected demographic characteristics, etc. As a result, frame stratification is limited as are some of the common features of modern telephone surveys, such as the ability to send advance letters to homes before a telephone call. Finally, in combining cell phones with a landline frame, households with no in-home access to a telephone remain excluded.

Second, the dual frame approach poses a number of operational challenges. Initial contact with cell phone households is limited to telephone contact, limiting the use of initial modes during the contact/recruitment phase of a study. While cell phones facilitate the continued use of CATI, these questionnaires will likely need to be shorter in duration as it is likely that respondents on cell phones will not participate in 20 to 30 minute (or longer) surveys as is common with many landline surveys. The cell phone must also be viewed as a new mode, with potential uses and constraints that differ from traditional landline interviewing. For instance, it's unclear the level of "cognitive engagement" respondents interviewed by cell phone have if they are multitasking or being interviewed while they are in an area of high distraction, such as while driving or shopping. Researchers also have yet to work out and agree upon a common set of disposition codes to cover situations which may be unique to cell phone interviewing (although work in this area is progressing). Likewise, how response rates are to be calculated, in particular the determination of the percentage of uncontacted numbers which should be estimated as eligible households and, therefore, be included in the denominator of a response rate. Additionally, there is still uncertainty as to whether or not within household randomization is an applicable concept with cell phone interviewing or if the devices should be treated solely as individual devices (which then raises the question of probability of selection within a cell phone only household in which an eligible sample member does not have their own cell phone and, therefore, would be

excluded from inclusion in a study). Finally, the level of participation in cell phone surveys is already quite low and can only be expected to decline over time if current trends in survey participation hold true for cell phones.

Perhaps one of the more problematic issues with cell phone sampling is the lack of universe estimates or population parameters against which to weight survey data. This is especially problematic at the sub-national levels (state, county, city, etc.). Moreover, dual frame weighting itself can be a rather complicated process even with good population parameters. Researchers are required, therefore, to either apply one of the few national estimates of phone ownership patterns to state and local areas or to develop synthetic or model-based estimates for external weighting standards. Again, this is an area of focus for a number of researchers (Frankel et al 2007; Brick et al 2007; Brick et al 2008).

Surveys conducted via sampling of cell phone exchanges are also much more expensive to conduct than the costs associated with a landline survey. A study conducted in three U.S. states found the costs to be nearly twice as high when screening for cell phone-only households was not conducted and nearly four times as great when such screening was used to identify cell phone-only households (link et al 2007). The study authors point to the lack of descriptive data on the cell phone frame typically used in prescreening of landline telephone numbers and low cooperation rates in surveys conducted over cell phones as two of the key factors driving the costs. Others have reported similar findings (Keeter 2008).

Cell phone interviewing also involves certain legal and ethical considerations that do not apply to traditional landline interviewing. For instance, the Telephone Consumer Protection Act and the FCC's implementation (71 Federal Reg 21634, April 26, 2006) prohibit machine-based dialing of cell phone numbers without prior consent from the respondent, a technique used by many survey research organizations to reduce costs and increase interview volume. These numbers need to be dialed by hand, thereby making them more expensive for the survey organizations who do call cell phones and impractical for organizations dealing with very large samples sizes (hand dialing is simply not a feasible options in these circumstances). The exception to this rule is if the number is provided by the respondent as the number at which they would like to be contacted. In these cases use of the autodialer may be permissible. Another consideration unique to cell phone calling involves respondent safety, as it is imperative to ensure that respondents are in a safe location or situation before proceeding with the interview. Finally, most US cellular calling plans require the cell phone subscriber to pay for incoming calls, raises a number of ethical and legal issues associated with soliciting cell phone subscribers without appropriate financial compensation.

In sum, it seems clear from the flurry of research in this area that many (most?) survey researchers who currently conduct landline RDD surveys are hopeful that a dual frame landline/cell phone approach can be developed to deal with the growing coverage crisis in RDD surveys. It is clear, however, that such an approach faces an array of obstacles, some methodological, some legal, and some societal. The approach may have short-term appeal, but its long-term prospects are still unclear.

3. Address Based Sampling (ABS)

Given the issues related to cell phone sampling, some researchers have begun to look at other options, foregoing the use of telephones as a primary sampling unit altogether (Link et al 2006; Link et al 2008). The growth in database technology has allowed the development and maintenance of large, computerized address databases, which may provide telephone survey researchers with an inexpensive, address-based sampling (ABS) alternative to RDD for drawing household samples. In particular, the Delivery Sequence File (DSF) used by the U.S. Postal Service (USPS) has proven most promising. The DSF is a computerized file that contains all delivery point addresses serviced by the USPS, with the exception of general delivery (USPS 2005). Each delivery point is a separate record that conforms to all USPS addressing standards, thereby facilitating the drawing of samples from any geography within the US using the same file structure.

From a sampling perspective, ABS using the DSF provides 98% coverage, based on internal studies conducted by Nielsen comparing a large nationwide sample of addresses with known addresses confirmed by Nielsen field staff. As such, ABS provides an alternative to sampling cell phone numbers as a cost-effective means of contacting cell phone only households, as well as providing access to households with no telephone and newly emerging VoIP-only based computer phones, groups that have here-to-fore been unreachable through traditional telephone survey methods. Because addresses are in a fixed location, telephone portability is not an issue.

Another important benefit of using an address-based frame is the rich amount of information that can be matched to an address, facilitating more complex sample designs and providing information for enhanced contacting and recruiting approaches. Perhaps most importantly, a majority (60+%) of addresses can be matched to a landline telephone number via commercial databases, thereby facilitating multiple modes of contact with many sampled households. In addition to matching landline telephone numbers to addresses, many survey sample vendors can also provide information at a case level variables such as household name, Spanish surname indicator, likely age of head

of household, as well as geocoding and attachment of Census tract information such as the percentage racial/ethnic groups within a particular geography, median household income of the area, and in some cases even email addresses. These variables can be used in a number of ways to enhance the survey design, such as through sample stratification on key variables, advance mailings to households, and tailoring of materials, contact scripts, or incentives based on household characteristics such as likely age, race, or ethnicity of the head of household. Based on a large scale pilot study, we determined that in terms of age indicators, a higher percentage of sampled addresses (than a comparison sample of RDD telephone numbers) had an age indicator available and that the accuracy of this indicator was greater (when compared to the age of head of householder provided by respondents in a subsequent survey) (Daily et al 2008). Similarly, with the Spanish surname indicator, a higher proportion of sampled addresses (compared to RDD) have a surname indicator, while the accuracy of this indicator is equivalent across ABS and RDD samples.

In terms of survey operations, ABS facilitates a number of potential survey designs. These can included single mode mail surveys to all sampled addresses; or a mail invitation to complete a mail or web survey; or, a dual mode design with mail surveys to all households (or just those with no matched telephone number) and telephone follow-up (or first contact) for those with an identifiable telephone numbers; or a more complex mix of mail, Web, interactive voice response (IVR), and outbound or inbound telephone. This gives researchers greater flexibility to match survey mode with the gals and target population for their study.

Weighting and post-survey adjustments can follow traditional survey procedures as population totals or universe estimates are readily available at the level of most commonly used geographies (national, state, county, DMA, etc.). Further, because of the near universal coverage the weighted data should more representative of the larger population from which the sample was drawn provided there is little or no systematic bias due to nonresponse.

In terms of cost, an equal number of sampled addresses about twice as expensive as an equal sample of telephone numbers, although this can vary broadly based on the sample vendor, number of cases sampled, and amount of additional data appended to each sampled case. In terms of total survey cost, however, the cost per sampled unit is minimal. Additionally, because of the efficiency of the frame (i.e., there are relatively few non-residential addresses if prescreening is conducted by the sample vendor), far fewer addresses (than telephone numbers) are required to reach a residential household. Moreover, ABS can facilitate survey designs which are less costly than RDD (or dual mode RDD & cell phone) survey to obtain the same number of completed interviews with the same survey instrument (Link et al 2008).

Address-based approaches do, however, have some drawbacks. DSF information cannot be obtained directly from the USPS, but must be purchased through a nonexclusive license agreement with private vendors. The quality and completeness of the address information obtained from these vendors varies widely depending on how often the company updates the listings, the degree to which the listings are augmented with information from other databases, and whether the company purges the records of householders who request that their information not be released (Link et al 2006). Vendors also differ in their experience with and ability to draw probability samples from the DSF list, which can be problematic if researchers do not wish to draw their own samples. The DSF contains post office (PO) box and multi-drop addresses (multiple persons associated with the same address), which may be problematic for in-person and telephone surveys where a street address is required to locate the household or an associated telephone number. Such addresses may be less problematic for surveys which use mail as the recruitment mode (such as with mail or Web surveys). Households with multiple mailing addresses (for example, a street address and a residential PO box) induce selection multiplicities in mail surveys. In some areas, households with a PO box likely do not receive home mail delivery. This circumstance may be more likely in rural areas where a PO box is provided at no cost and no home mail delivery is made. Thus, including PO boxes may be necessary to ensure coverage of all households.

From an operational perspective, ABS can limit the ability of a research organization to conduct quick turnaround studies. While a majority (60+%) of the sampled addresses can be matched to a telephone number, the remaining 40% must be contacted/recruited first by mail regardless of the actual survey mode used for data collection. This process takes time. As an alternative, an organization can conduct on-going pre-recruitment efforts with these "unmatched" cases (i.e., those with no matched telephone number), obtaining telephone contact information from respondents and providing a ready bank of numbers from which to sample for this portion of addresses. This is, however, a relatively expensive and somewhat complex proposition.

If limited to mail-only, many surveys would also need o be adjusted in terms of length and complexity, as longer, more complex surveys are not readily feasible with a paper-and-pencil approach. Use of a Web survey option and/or a call-in number to a CATI interviewer can alleviate this problem, however, only households with Web access would be able to use the former approach and very few respondents are likely to call in to complete a survey with the latter design.

As is the case with cell phones, use of address based sampling also requires modification of standard disposition codes (even the American Association for Public Opinion Research's [AAPOR] current disposition list for mail surveys is inadequate as the list only applies to mail surveys where the respondent is known) and a reassessment of response rate calculations as there is currently no agreed upon industry standard for determining the percentage of noncontacted addresses (excluding those for which a post office return was received) to include in the denominator of a response rate.

Several studies have compared ABS to RDD as a means of conducting surveys of the general population (Link et al 2006; Link et al 2008; Shuttles et al 2008; Daily et al 2008). The ABS survey design proposed by Nielsen for replacement of its current RDD-based TV Ratings Diary survey is one which utilizes mail, Web, outbound, and inbound telephone components. Households are sampled via their address and matched to commercial databases to identify a landline telephone number. Those without a telephone match (the large majority of which are cell phone only and unlisted landline telephone households) are sent a one page pre-recruitment survey, requesting additional contact information, including a telephone number (which may be landline or cell phone), which can be returned via mail, a Web site, or by calling a help desk agent via a toll free number. Households with a matched telephone number or who return a telephone number through the pre-recruitment process are contacted via telephone and recruited for the Nielsen TV Ratings Diary survey. Households are then mailed the Diary (including households with a valid address which may have refused at the telephone stage or not been contacted by telephone), which they keep for a week and return via mail (see Shuttles et al 2008 for more details). The design has been shown to reach cell phone only households and those without telephone access, with response rate at or above those for current RDD methods (Daily et al 2008).

4. Conclusions

While it would likely be a mistake to declare that the sun has set completely on landline RDD methodology, it is clear that the approach has serious, seemingly non-recoverable problems in terms of coverage and declining response rate. This is not to say that "telephone surveys" are nearing their end, but rather the reliance on the landline telephone frame as the sole basis for drawing samples for conducting surveys of the general population is in question. The telephone as a mode for conducting interviews is not what is at issue; what is in question is what survey design (or designs) will replace landline RDD as the workhorse for the survey industry. Given the considerable cost of conducting in-person interviews, that mode is likely to remain reserved for only the best funded projects. At the other extreme, use of online surveys based on non-probability, opt-in sample designs is likely to remain a niche methodology for the foreseeable future. Based on the amount of published literature and presentations at industry conferences, such as that of AAPOR, the front-runner appears to be a dual frame design combining landline and cell phone frames. In contrast, we propose the use of address based sampling as an alternative to telephone-based sampling as a means of overcoming or minimizing some of the potential problems caused by sampling of cell phones. As we have discussed, both have their advantages and disadvantages -- some which can be resolved with time and additional research, others which may be intractable.

In the end, the use of a dual-telephone frame approach or an address based approach to sampling comes down to how well each fits the requirements of the research at hand, in terms of cost, quality, and timeliness. What may work well for one research endeavor may not match the needs of another. As a short-term solution, sampling of cell phone exchanges may provide a stop-gap for those conducting smaller to moderate-sized surveys (hand dialing of numbers is prohibitive for most large-scale studies) until a more stable, longer-term methodology is refined. We believe that ABS is the base upon which such a methodology (or set of methodologies) can be built, providing a stable sampling base, a rich source of characteristic and geographic data for facilitating sophisticated designs, and an opportunity to utilize multiple modes for contacting and conducting surveys with households.

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Table 1. Cell Phone Sampling: Positive and Negative Attributes

Benefits/positive attributes	**Concerns/negative attributes**
Sampling considerations	
Improves coverage over landline only sampling – estimated 95% coverage with dual frame approach	Inefficient frame – many units expired, not in service, etc.
Telephone numbers available for all sampled cases	Little or no sample frame information for stratification or targeted sampling
	Number may not necessarily be tied to a specific geography
	Excludes those with no telephone
Operational considerations	
Better for quick turnaround studies	Mode effects – cell phone is new mode
Facilitates continued use of CATI	Low response rates
Facilitates continued use of complex questionnaires	Questionable level of cognitive engagement; potential for increased distractions
Facilitates contact with "on-the-go" respondents who may be difficult to reach at home	Likely to reduce length of potential questionnaires
	No address matching/no advance mailing possible
	No additional follow-up by other modes possible
	No names available
	Likely to reduce length of potential questionnaires
	Uncertain within household selection rules
	Calling windows are uncertain if respondent is not in the time zone associated with the area code (temporary travel can compound this problem)
	Additional call outcome dispositions need for outcomes unique to cold calling of cell phones
	Response rate calculations may need to be adjusted; unclear how to properly calculate the percentage of noncontact numbers to include in the response rate denominator.
	May limit ability to use Caller ID signaling to identity of the research company making the calls.
Weighting & adjustment considerations	
	No universe estimates for weighting, particularly at subnational level
	Dual frame weighting process can be complicated.
Cost considerations	
Cost per unit sampled number slightly more than landline RDD sample	Costly to conduct, especially if screening for cell only HHs
	Compensation for air time strongly encouraged
Legal/ethnical considerations	
	Concerns about respondent safety if reached in an "unsafe" location, such as while driving
	Legal constraints, particularly with autodialing cold sampled numbers

Table 2. Address Based Sampling: Positive and Negative Attributes

Benefits/positive attributes	**Concerns/negative attributes**
Sampling considerations	
Provides 98% coverage of residential households	Small degree of multiplicity (due to HHs with PO box & city address – reduced if throwback units dropped)
Reaches cell phone only households	
Geography is fixed	
Address type allows for subsampling efficiencies	
Highly efficient frame – nearly all are residential	
Can match to landline telephone numbers (60+%)	
Reaches residential addresses with no telephone service	
Reaches households with VOIP/Internet-based phones	
Operational considerations	
Several sample indicators available (age, surname, etc.), which can be used to stratify the sample or drive special treatments (such as targeted incentives or materials)	Potentially limits complexity of questionnaire for HHs with no available telephone number – but Web questionnaire can reduce this problem
Accuracy of indicators for age & Hispanic surname better than for RDD	Can only match addresses to landline telephone numbers
Names available	Potentially limits ability to use CATI for HHs with no available telephone number
Facilitates multiple channels of contact	Potentially slower turnaround/longer field period required for unmatched cases
Facilitates multiple modes of data collection	Unmatched cases with no telephone numbers limited initially to mail contact
Can obtain cell phone numbers / contact info from respondents by mail	Response rate calculations may need to be adjusted; unclear how to calculate the percentage of nonreturns to include in the denominator.
	Additional call outcome dispositions needed to handle outcomes unique to address-based approach
	Potentially greater logistical/operational complexity than telephone approach.
Weighting & adjustment considerations	
Standard survey weighting procedures can apply (minimal complexity)	
Weighting more accurate due to near universal coverage	
Cost considerations	
Cost per unit sampled number slightly more than landline RDD sample	
Can facilitate cost reductions over RDD depending on design	
Legal/ethnical considerations	
If cell phone provided by respondent, no legal restrictions on calls	