# Cell Telephone Response Rates

Martin Barron[1], Meena Khare[2], Zhen Zhao[3]
[1]NORC at the University of Chicago, 55 E Monroe, Chicago IL 60626
[2]National Center for Health Statistics, Room 3119, 3311 Toledo Road, Hyattsville, MD 20782
[3]National Center for Immunization and Respiratory Diseases, Corporate Boulevard, Atlanta, GA 30329

## Abstract[1]

Though cell telephone surveys and traditional, landline telephone surveys have many similarities, cell telephone surveys include unique features that must be taken into account when calculating response rates. In addition, events common to both cell telephone and landline telephone surveys may have different meanings (for example, the meaning of a ring-no-answer). This paper describes the operational issues of calculating response rates for the National Immunization Survey's (NIS) Cell Telephone Pilot study. We discuss the advantages and disadvantages of calculating cell telephone response rates on a household-level versus on a person-level. We also discuss the differential meaning of events in a cell versus landline survey, estimating eligibility among unscreened households (*e*) and how the calculation of final disposition codes and response rates are influenced by these factors. Our practical experience is meant to encourage discussion on developing a standardized method for calculating cell telephone response rates.

**Key Words:** Cell Telephones, Response Rate, National Immunization Survey

## 1. Introduction

The prevalence of cell telephone-only households has grown incredibly overthe last five years. During the first half of 2003, 2.9% of adults lived in cell-only households (Blumberg and Luke 2007a). By the first half of 2007, the proportion had increased to 12.6% (Blumberg and Luke 2007b).The growth in cell-only households has led to coverage concerns with random digit dial (RDD) surveys, as these surveys have traditionally excluded cellular telephone numbers. Thus, many organizations with RDD surveys have begun experimenting with the addition of cellular telephone numbers to their sampling frame.

Conducting surveys with cell telephone numbers raises a number of practical considerations. One of these is the appropriate calculation of response rates. Though cell telephone surveys have much in common with traditional, landline-telephone surveys—perhaps suggesting to some researchers that landline telephone survey response rate calculations can be applied indiscriminately to cell telephone surveys—enough differences exist that the adoption of existing procedures must be done with extreme care.

This paper draws on experience from the National Immunization Survey's Cell Telephone Pilot study (NIS-CTP) to explore the calculation of response rates for cell telephone surveys. We concentrate our discussion on three aspects of response rate calculations. First, we discuss the distinction between considering a cell telephone as a personal device versus as a device tied to a household and the implication of that choice for rate calculations. Second, we explore the different meaning of certain telephone events in cell telephone surveys and landline surveys and how this influences response rate calculations. Third, we discuss the estimation of eligibility rate among unscreened cell telephone numbers (referred to as *e*) and how this may differ from landline surveys.

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

## 1.1 Background

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

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

Households with children age 19 to 35 months are an extremely rare population[2]. Thus a disproportionate amount of NIS data collection is dedicated to the screening of households with young children. In 2007, the NIS dialed approximately 4.5 million telephone numbers, screened 850,000 households, and completed 24,000 interviews in order to generate vaccination estimates for the nation, 50 states, and 13 local areas.

## 1.2 NIS Response Rates

The NIS assigns an event code to each call attempted, and the cumulative history of these events is used to calculate each telephone number's final disposition. The final dispositions can be collapsed into one of the nine categories shown in Table 1. These categories are the basis for all NIS rate calculations.

**Table 1: NIS Final Dispositions**

| Disposition Code | Description |
|---|---|
| D | Non-working, Out-of-Scope |
| NR | Non-residential |
| NC | Non-contact |
| I | Answering Machine |
| U1 | Known Household, unscreened |
| U2 | Likely Household, unscreened |
| J | Ineligible Household |
| ER | Household Partial |
| C | Household Complete |

The NIS reports Council of American Survey Research Organizations (CASRO) response rate type II (Frankel 1983). This rate can be expressed as the product of three component rates: resolution rate, screener completion rate, and interview completion rate (Battaglia *et al*., 2008). Equation 1 summarizes these rates.

**Equation 1: Components of CASRO Rate Type II**

$$\frac{\text{Resolved numbers}}{\text{Total sample of telephone numbers}} * \frac{\text{Screened households}}{\text{Known households}} * \frac{\text{Completed interviews}}{\text{Eligible households}} = \text{CASRO Rate Type II}$$

OR

[2] Based on Current Population Survey data, the estimated household eligibility rate in 2007 was 4.6%.

$$\frac{D + NR + U1 + J + ER + C}{D + NR + NC + I + U1 + U2 + J + ER + C} * \frac{J + ER + C}{U1 + J + ER + C} * \frac{C}{ER + C} = \text{CASRO Rate Type II}$$

The American Association for Public Opinion Research (AAPOR) standard response rate definitions (2008) provide six formulas (RR1 – RR6) for calculating response rates. Each of these conforms to the general definition of a response rate as "completed interviews divided by eligible units." However, they vary in both their definition of a completed interview and of eligible units. These differences are summarized in Table 2.

**Table 2: Summary of AAPOR Response Rates**

| | All unobserved units considered eligible | Unobserved units considered eligible proportional to observed units | No unobserved unit considered eligible |
|---|---|---|---|
| Full completes only | RR1 | RR3* | RR5 |
| Full completes & partials considered complete | RR2 | RR4 | RR6 |

* equivalent to CASRO rate Type II

CASRO response rate type II can be shown to be equivalent to AAPOR Response Rate #3 (RR3) , where partials are not considered completes and unobserved units are consider to be eligible proportional to the eligibility among observed units (Battaglia 2008). Since the NIS must screen for both household status and presence of children in the appropriate age range, the eligibility assumption implies that the eligibility of households unscreened for eligible children (*e*) is equal to the eligibility rate among the screened sample (epsilon or $\varepsilon$) and the eligibility among telephone numbers unscreened for residential status is equal to the product of the residential rate among resolved numbers (delta, or $\delta$) and the eligibility rate among screened households (epsilon, or $\varepsilon$). This formula is expressed in equation 2.

**Equation 2: CASRO Type II/AAPOR Response Rate #3**

$$\frac{C}{C + ER + (U1 \cdot \varepsilon) + ((NC + U2 + I) \cdot \delta \cdot \varepsilon)}$$

*where*

$\delta$ = observed residential number rate = $\dfrac{C + ER + J + U1}{C + ER + J + U1 + D + NR}$

$\varepsilon$ = observed eligibility rate = $\dfrac{C + ER}{C + ER + J}$

## 1.3 NIS Cell Telephone Pilot

As with other RDD surveys, the NIS has also been greatly concerned with the increase in prevalence of cell telephone-only households. Thus, in 2007, the NIS undertook a pilot study to assess operational procedures for conducting a cell telephone survey and to gain practical experience with collecting vaccination information via cell telephones.

The pilot study interviewers dialed 49,399 cell telephone numbers in the state of Illinois during the second half of 2007 and early 2008. The pilot study took place in three separate waves[3], which are summarized in Table 3. In all waves, a shortened NIS interview was fielded to screen the household, ask several broad vaccination questions, request consent to contact child's provider, and collect socio-demographic information. Though respondents were

[3] The primary purpose of wave 1 was to test systems and procedures. Thus no provider data were collected in that wave and it was not used for vaccination estimation. Therefore, other papers describing the NIS Cell Phone Pilot (e.g. Barron 2008) do not include this wave.

asked if they lived in a cell telephone-only household, those living in mixed households (with access to landline and cell telephones) were not screened out. The interview took approximately 10 minutes to complete.

**Table 3: Summary of NIS Cell Telephone Pilot Study Waves**

| Pilot Wave | Field Dates | Sample Size | Summarized Design |
|---|---|---|---|
| Wave 1 | 8/14/2007 - 9/26/2007 | 9,300 | • Original introduction<br>• Interviewed mother or femaleguardian<br>• Five dollar incentive<br>• Compressed calling rules |
| Wave 2 | 11/15/2007 – 12/23/2007 | 20,099 | • Revised Introduction 1<br>• Interviewed mother or female guardian<br>• Five dollar incentive<br>• Expanded calling rules |
| Wave 3 | 1/28/2008 – 3/10/2008 | 20,000 | • Revised Introduction 2<br>• Interviewed mother or father or guardian of either gender<br>• Ten dollar incentive<br>• Expanded calling rules |

Table 4 summarizes the final dispositions and response rates for the NIS Cell Telephone Pilot both for individual waves and combined.

**Table 4: Final Disposition Codes and Response Rates by Waves of the NIS Cell Telephone Pilot Study**

| Code | Description | Wave 1 | Wave 2 | Wave 3 | Total |
|---|---|---|---|---|---|
| DIAL | Dialed Cases | 9,300 | 20,099 | 20,000 | 49,399 |
| D | Non-working | 3,297 | 6,621 | 6,008 | 15,926 |
| NR | Non-residential, Out-of-Scope | 253 | 820 | 811 | 1,884 |
| NC | Non-contact | 67 | 443 | 332 | 842 |
| I | Answering Machine | 1,378 | 3,363 | 2,927 | 7,668 |
| U1 | Known Active Cellular Line | 2,941 | 5,699 | 5,506 | 14,146 |
| U2 | Likely Active Cellular Line | 68 | 474 | 434 | 976 |
| J | Ineligible | 1,263 | 2,602 | 3,804 | 7,669 |
| ER | Partial Interview | 6 | 23 | 47 | 76 |
| C | Interview Complete | 26 | 54 | 131 | 211 |
| **Production Rates** | | | | | |
| $\varepsilon$ | Eligibility Rate | 2.5% | 2.9% | 4.5% | 3.6% |
| $\delta$ | Working Personal Cell Number | 54.4% | 53.0% | 58.2% | 55.4% |
| RES | Resolution Rate | 83.7% | 78.7% | 81.5% | 80.8% |
| COM | Interview Completion Rate | 81.3% | 70.1% | 73.6% | 73.5% |
| SCR | Screening Rate | 30.6% | 32.0% | 42.0% | 36.0% |
| RR1 | AAPOR RR1 | 0.6% | 0.5% | 1.4% | 0.9% |
| RR3 | AAPOR RR3 (CASRO) | 20.8% | 17.6% | 25.2% | 21.4% |
| RR5 | AAPOR RR5 | 81.3% | 70.1% | 73.6% | 73.5% |

## 2. Cell Telephone Survey Response Rates

We now turn to the calculation of response rate for cell telephone surveys. Our discussion is divided into three issues confronting researchers when calculating response rates for cell telephone surveys. First, we discuss the distinction between considering a cell telephone as a personal device versus a device associated with a household and the implications of that choice for rate calculations. Second, we explore the differential meaning of certain telephone events in cell telephone surveys versus landline-telephone surveys and how this influences rate calculations. Third, we discuss the estimation of eligibility among unscreened cell telephone numbers (*e*) and how this may differ from landline surveys.

### 2.1 Household versus Personal Device Coding

One of the first problems to confront researchers as they plan for a cell telephone survey is whether to treat a cell telephone as a personal device–tied to an individual–or similar to a landline telephone (tied to a household).

RDD surveys have traditionally treated landlines as tied to households for the purpose of rate calculations (AAPOR response rates guidelines only discuss RDD surveys of households). Once a household is contacted, an additional selection step may take place to reach a particular person living in the household–the head-of-household or a randomly selected resident, for example– but the base unit for rate calculations is the telephone number, which is tied to a particular household. This is certainly a reasonable procedure as landlines are naturally tied to a particular physical location[4]. Cell telephones, on the other hand, are clearly not linked to a particular physical location, though they could be considered tied to a household through their users (i.e., the cell telephone inherits the household membership of its user(s)).

Thus, researchers are faced with a choice: treat cell phones as tied to an individual or treat them as tied to a household. There are pros and cons to each approach. For ease of weighting and combining with a comparable landline sample, treating cell phones as tied to one household address is certainly the most straightforward approach. By treating cell phones as belonging to only one household, the primary sampling unit remains consistent: the household. Upon contacting a cell telephone respondent, the person could then be asked screening questions related to the household and, where appropriate, another household member could be selected. Selecting a new household respondent, however, poses significant challenges that do not exist for landlines. Most obviously, an initial respondent may be contacted when not at home or in proximity to other household members. This may cause confusion or cognitive difficulty when asking about the person's "household" and may make it more difficult to reach the subsequently selected respondent.

On the other hand, many cell telephone users *do* consider a cell telephone to be a personal device. In focus groups conducted by NORC of cell telephone-only users, most participants expressed some degree of discomfort with sharing their phone with others and expressed great concern with providing additional contact information to allow the interviewer to contact another household member (NORC 2007). Of course, contacting a selected household member through a gatekeeper is always difficult, and even when a landline is contacted, there is no guarantee that the other household member will be home.

Furthermore, even if many cell telephone users consider their phones personal devices, some cell telephones are shared with other household members. NORC focus groups among cell-only households found sharing to be quite common. Thus, one can easily imagine a cell telephone-only household with only one phone shared among household members. If cell telephones are treated as personal devices and the first call to that number happened to reach an ineligible resident, for example, that number would be coded as out-of-scope and all other residents of the household would effectively be excluded from the sample frame.

Whatever route is chosen, there are ramifications for rate calculations. First, as noted earlier, AAPOR RDD rate definitions are based upon household sampling. Thus, if cell phones are considered a personal device, assumptions about the units for rate calculations changes. Second, the definitions of certain final dispositions and events may differ depending on which approach is adopted. For example, if treated as a personal device, it obviously no longer

[4] Though some ambiguities, such as call forwarding, exist.

makes sense to assign a disposition to the case as a known or unknown household. Finally, the value of *e* (the eligibility among unscreened units) will also vary depending upon which approach is adopted (this is discussed in more detail below).

For the NIS Cell Telephone Pilot, staff decided to consider a cell telephone a personal device. Our preliminary research demonstrated a strong aversion among cell users to treating cell phones as tied to a household. Also recall that the primary purpose of the NIS is to locate children age 19 to 35 months and to contact their immunization providers to obtain vaccination information. Since our ultimate analytic unit is the child, we felt that we could bypass the household-level selection phase in order to select a parent or guardian who would report on a particular child.

## 2.2 Cell Telephone Event

All response rates are calculated based upon disposition codes assigned according to "events" that occur when a sampled telephone number is dialed by an interviewer (e.g., busy signal, answering machine reached, completed interview). How those events are interpreted and categorized is thus a central question for the calculation of response rates.

As noted above, the NIS adopted a person-centric view of cell telephones. This required small changes to the labeling of final dispositions (reflected in Table 4 and Table 5). Though this did not impact the formula used to calculate response rates, it did have meaning for the categorizing of events into certain categories.

Prior research (Callegaro *et al.,* 2007) has shown the need for additional event codes when conducting cell telephone surveys. Specifically, it points to the ambiguity of operator messages received when dialing a cell telephone. These operator messages are created by individual cellular carriers and therefore can have ambiguous or even differing meanings assigned to them depending upon the number dialed.

**Table 5: NIS Cell Telephone Pilot Final Dispositions**

| Code | Description |
|---|---|
| D | Non-working, Out-of-Scope |
| NR | Non-residential |
| NC | Non-contact |
| I | Answering Machine |
| U1 | Known Active Cellular Line, unscreened |
| U2 | Likely Active Cellular Line, unscreened |
| J | Ineligible Household |
| ER | Partial Interview |
| C | Complete |

The NIS Cell Telephone Pilot adopted a series of seven event codes to capture cell telephone-specific events and the complexity of cell telephone operator messages. Table 6 displays these events and their assigned disposition. We also display the number and percentage (of all events) of each of these events that were experienced on the NIS Cell Telephone Pilot

**Table 6: NIS Cell Telephone-Specific Event Codes**

| Event Description | Minimal Disposition Coding | No of Events |
|---|---|---|
| Cell Phone Other Technological Circumstances - Dropped call | U1 | 99 (.05%) |
| Cell Phone Other Technological Circumstances - Audio quality too poor to continue | U1 | 119 (.06%) |
| Message - Out of Range/Out of Area/Out of Coverage/Roaming | U2 | 0 (0%) |

| | | |
|---|---|---|
| Message - The telephone number does not accept incoming calls | U2 | 1,277(.63%) |
| Message - Cell phone is temporarily not working/temporarily unavailable | D | 6,963(3.45%) |
| Message - Number not in service | D | 11,574(5.73%) |
| Message - Number cannot be reached from our calling area | U2 | 1,183(0.59%) |

In addition to new events, the meaning of existing events may vary between landline-telephone surveys and cell telephone surveys. For example, the meaning of refusals varies. At the household level, a refusal certainly indicates an active line, but says nothing about the household status of the number. Thus, on the NIS, this number would move to a minimal disposition of "likely household, unscreened." However, since the NIS treats cell telephones as tied to the individual, the differentiation between known and likely unscreened households is irrelevant. Instead, we differentiate between known and unknown active cellular lines. In such a case, a refusal indicates a known active cellular line but only would indicate a likely household. Such a difference has rate implications as known cellular lines/known household are considered resolved, but not screened (therefore increasing the study's resolution rate but reducing its screener rate) while likely cellular lines/likely households are considered unresolved (therefore negatively impacting the resolution rate but not the screener rate).

Another, more ambiguous example is a ring-no-answer. On landline telephones, a ring-no-answer typically indicates an operational phone line where the respondent is not available to answer the call. As virtually all US cell telephones include voicemail service, the meaning of ring-no-answer is much less clear for cell telephone surveys. Indeed, given differences between carriers, the meaning may vary from carrier to carrier. This could substantially alter response rates if, for example, a number of non-operational cell phone number were incorrectly coded as non-contact cases due to ring-no-answer events.

## 2.3 Calculating the Eligibility Rate 'e'

Finally, we turn to a discussion of the calculation of the eligibility rate, *e*, among unobserved sample. As noted above, the NIS uses CASRO type II calculation, which assumes that the eligibility rate among unobserved sample is equal to the eligibility of observed sample. Smith (2003) has argued that this approach is conservative as it assumes that unobserved units are similar to observed units when the only piece of available information (the units' reachable status) varies between the two groups. Thus this approach likely overestimates the eligibility of unobserved units.

Alternative approaches exist. One could take the extreme approach of considering all unobserved units eligible (RR1) or, alternatively, considering them all ineligible (RR5) or presenting both to demonstrate the potential range of response rates. Other approaches include using survival analysis to estimate the probability that unobserved cases are eligible.

The NIS Cell Telephone Pilot adopted the CASRO type II assumption that the eligibility rate among unobserved units is equal to the rate among observed children. Under this assumption, the NIS Pilot study's CASRO (RR3) response rate was 21.4%. Had we made a different assumption, our response rate could have varied from a low of 0.9% (RR1 where all unobserved units are considered eligible) to a high of 73.5% (RR5 where no unobserved units are considered eligible).

The AAPOR task force on cell phones recommends using RR1 for cell studies, given the uncertainties surrounding cell telephone response rate calculations (AAPOR 2008b). While this is a reasonable approach for general populations surveys it is inappropriate for surveys of specific subpopulations (such as the NIS) as it assumes all unobserved cases are eligible.

# 3. Discussion

In this paper we have discussed three components of response rate calculations and some considerations when dealing with cell telephone surveys. Each of these—treating cell telephones as personal or household devices, the meaning and categorizing of events, and the calculation of eligibility among unobserved sample—can have significant impact on the rate calculations of cell telephone surveys. In addition, other factors not discussed here can also play a crucial role (such as multiple cell telephone individuals). Researchers must consider the full breadth of issues when implementing cell telephone surveys and calculating appropriate response rates.

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