

Analysis of Call Patterns in a Large Random-Digit-Dialing Survey: The National Immunization Survey

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1. Introduction

Call patterning in random digit dial (RDD) telephone surveys involves scheduling one or more call attempts according to a predetermined sequence. Call patterns may also be conditioned on demographic information at the level of the telephone exchange.² Ideally, call patterning minimizes the number of call attempts required to have an adult respondent answer the phone and then complete the eligibility screener and, if appropriate, the interview. An optimal call pattern results in the highest response rate against the number of call attempts, given resource constraints and response-rate goals. A CATI call scheduler based on analyses of calling patterns has the potential to reduce the costs of a RDD survey without compromising the household contact rate or the response rate. Optimal call patterns may be identified through analysis of contributing influences such as the timing of call attempts, seasonality, and environmental factors associated with telephone exchanges such as median household income, urbanicity, geography, etc.

To identify optimal call patterns, we analyzed the call record files of the National Immunization Survey. The NIS employs a large RDD telephone survey having 9am-9pm/7-days-a-week coverage for all 50 States and the District of Columbia. Results show the rank ordering of call patterns by the probability of household contact, case resolution (household/non-residential/non-working), screener completion, and interview completion. Also examined is the usefulness of demographic information available at the telephone exchange level for scheduling the first call attempt.

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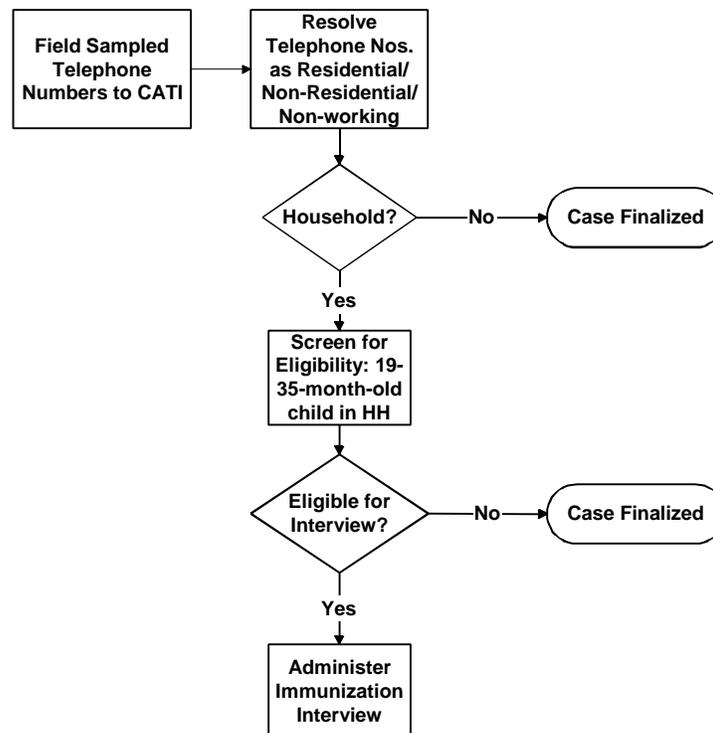
² A telephone exchange consists of the first six digits of a telephone number, starting with the area code.

2. General Information about the National Immunization Survey

Sponsored by the National Immunization Program and the National Center for Health Statistics (both of the Centers for Disease Control and Prevention), the NIS provides rolling four-quarter estimates of vaccination coverage for children ages 19-35 months for each of the 78 Immunization Action Plan (IAP) areas. The 78 IAP areas are geographical areas defined by the 50 states and 28 selected metropolitan areas (Ezzati-Rice et al., 1995). The sample of telephone numbers for each of the 78 IAP areas requires separate monitoring because each IAP area displays unique characteristics in terms of household eligibility and response rates.

In operation continuously since 1994, the NIS uses a list-assisted random-digit dialing telephone survey of households having age-eligible children and a provider record check study that validates self-report data on children for whom consent has been obtained during the RDD interview. Sample preparation involves prescreening for non-working and known business numbers using the GENESYS system (Marketing Systems Group). Households having children between the ages of 19 and 35 months are eligible for the interview. Exhibit 1 shows an overview of the RDD data collection process.

Exhibit 1: Overview of the RDD Data Collection Process for the NIS



The sample management and call scheduling systems used on the NIS reflect the requirement to separately monitor each of the 78 IAP area samples (Buckley 1998). In addition, the systems reflect the large scale of the RDD study and the fixed quarter-based schedule for providing vaccination coverage estimates. The scale of the study in large measure is the result of the relatively low eligibility rate (less than 5% of screened households have age-eligible children). To complete approximately 35,000 interviews a year, the NIS places about 12 million calls to 1.9 million telephone numbers, screening approximately 1,000,000 households. These efforts require the preparation of more than 600,000 sample telephone numbers per quarter. To conduct the calling, a very large interviewing staff and numerous telephone supervisors are dedicated to RDD telephone production.

Below are some of the key indicators of the telephone data collection process.³ The mean number of call attempts is 4.95 calls per fielded case, 3.1 calls to contact a household, 3.4 calls to complete an eligibility screen, and 5.6 calls to obtain an interview. By the 5th call attempt, 69% of interviews are completed; by the 10th attempt, 86%; by the 25th, 97.6% of interviews are completed (Dennis, 1999).

3. Previous Research on Optimal Call Patterns in RDD Surveys

Calling patterns optimizing on the rate of household contact were analyzed using NIS data by Massey et al. (1996). The research in this paper was based on a population-based estimate of the percentage of sampled telephone numbers that are household numbers. Massey's research on NIS call patterns led to the present NIS CATI scheduler and to the call patterns observed in the data used for the present paper. Consequently, the relatively narrow variation among the call patterns seen in the results is in part a reflection of Massey's research since his main findings were used for programming the NIS CATI call scheduler.

Kulka and Weeks (1988) provide a sophisticated conditional probability approach based on a RDD sample of approximately 190,000 telephone numbers. Kulka and Weeks found that weekday evenings had the best contact rates on first call and second call attempts, except when the first call is also made during weekday evenings.

4. Data Sources

The data sources for this research are based on work conducted on the National Immunization Survey for data collection quarters Q4/1996 through Q3/1997. The data sources are the study's

³ For NIS data collection quarters Q4/1996-Q3/1997.

electronic record of calls and Census information available at the level of the telephone exchange.

- **Record of Calls.** A summary file was created fully describing the call history results of each sampled telephone number (1.7 million) fielded during Q4/1996-Q3/1997. Approximately 9.5 million call attempt records were synthesized to create the file. This file contains variables for the day of week/time of day cell and the outcome of the first three dial attempts as well as the same information for the last dial attempt. The file also indicates the dial attempt number for which each case was first contacted (households only), resolved, screened, and interviewed and also records each incurred refusal.
- **Census Data.** Each quarter, the NIS sample frame vendor, Marketing Systems Group, Inc., supplies updated Census zip code information mapped to the telephone exchanges that are included in the NIS sampling frame. A file was created having a record (133,962) for each telephone exchange in the sampling frames used for the quarters Q4/1996-Q3/1997. Three sample frames were used to create the sample for those quarters; therefore, there are at most three records containing Census information for a given exchange. We constructed the file such that when the geographical definition of a telephone exchange changes, the Census information for telephone numbers within that exchange also changes. Approximately 85% of the available exchanges are drawn into the sample each quarter. The data are used to create exchange-level variables for MSA status, median household income, and other demographic characteristics.

5. Discussion of Analytical Methods

The methods employed for the results presented in this paper involve, first, characterizing call outcomes for the first, second, and third call attempts for all cases in the record of calls file. The timing of the call attempts are then coded using a 28-cell, day of week/time of day classification scheme based on the following segments for each day of the week (respondent local time): 9am-noon; noon-4pm; 4pm-6pm; 6pm-9pm. The NIS does not have information on the utility of placing calls after 9pm.⁴

Exhibit 2 shows the time cells that are included in the single-call analyses. The average sample size for the included time cells is almost 93,000 "first-time-in" cases. The range is from 10,000 to 201,000. A cut-off of 10,000 cases is used to assure adequate sample size for the first-call analyses.

⁴ Other research firms may have protocols that allow for calling after 9pm respondent local time. The NIS does not place calls after this time unless the respondent has requested an appointment.

Exhibit 2: Time Cells Used (Blue) and Excluded (White) in the First-Call Analyses⁵

RESPONDENT LOCAL TIME	SUN	MON	TUE	WED	THU	FRI	SAT
9AM-NOON							
NOON-4PM							
4PM-6PM							
6PM-9PM							

All call attempts were also classified by call outcome as follows :

- **Household Contact/Non-Contact.** A *contact* is defined as a contact with an actual adult respondent (i.e., excluding answering machines) in a known household. Contacts with non-residential sample are excluded.

$$\text{Household Contact Rate} = \frac{\text{Number of Cases Resolved As Households by Speaking with Adult}}{\text{Number of Cases Fielded}}$$

- **Resolved/Not Resolved.** A case is *resolved* when an interviewer determines that the sampled telephone number is associated with a household, non-residential unit, or is out of scope (e.g., a non-working phone number).

$$\text{Resolution Rate} = \frac{\text{Number of Cases Resolved as Households, Business or Non-working}}{\text{Number of Cases Fielded}}$$

- **Screener Completed/Not Completed.** A case resolved to be a household is successfully *screened* when the household is determined to be eligible or ineligible for the interview.

⁵ Certain time cells are excluded because the number fielded of first-dial cases is fewer than 10,000: all seven days from 9am-Noon; Friday Noon-4pm; Friday 4-6pm; and Sunday 4-6pm.

- ***Interview Completed/Not Completed.*** A case eligible for the interview is successfully *interviewed* when the immunization questionnaire is completed. Interview administration time averages approximately 20 minutes.

The 28-cell classification scheme allows for the calculation of rates for household contact, resolution, screener completion, and interview completion by the first-call attempt or by multiple-dial combinations of the 28 day of week/time of day cells. The CASRO response rate is provided for the first-call analysis; it is defined as the composite rate obtained by multiplying the rates for resolution, screener completion, and interview completion (Ezzati-Rice 1999).

In examining the methodology for computing resolution rates based on three-dial calling patterns, we sought to address the issue of giving appropriate credit to each three-dial calling pattern. Including in the analysis only those cases that received at least three attempts would obscure the true effectiveness of a given calling pattern since it would not credit a calling pattern for cases resolved on the first or second call attempt.

The method employed in this paper addresses this issue. By including cases resolved after the first or second attempt, proper credit can be given to those one- and two-dial patterns that result in resolved cases. This method has the additional benefit of allowing comparisons between several three-dial patterns for which the day and time of the first two call attempts are identical.

For a given three-dial call pattern, the resolution rate is calculated by defining:

- Call 1 at Day/Time A
- Call 2 at Day/Time B (of those numbers not resolved at call 1, called here)
- Call 3 at Day/Time C (of those numbers not resolved at call 2, called here)

Number of cases resolved=

- actual number resolved at Call 1
- plus projected number resolved at Call 2 (product of resolution rate at call 2 and number of unresolved cases after call 1)
- plus projected number resolved at Call 3 (product of resolution rate at call 3 and number of unresolved cases after call 2)

After calculating the resolution rate for the first dial attempt, the resolution rate of the second attempt is determined by asking how many cases would have been resolved if all of the cases that were unresolved after the first dial attempt received their second attempt at Call 2. The same step is taken for the third dial attempt.

The three-dial call patterning analysis of resolution involves almost 22,000 possible day of

week/time of day combinations. For example, a common three-dial call pattern for the NIS is Monday evening/Tuesday afternoon/Tuesday evening. Because of call patterning already in use by the NIS (based on research conducted by Massey), not all day of week/time of day cells are sufficiently represented to be included in the analysis. Three-dial patterns that had fewer than 1,000 dial attempts on the third dial attempt are excluded from the analysis. Also excluded are those patterns that result from common appointment patterns (i.e., the first two dial attempts occur in the same cell because of callbacks). After these exclusions, 104 three-dial call patterns remained for analysis of optimal call patterns.

Finally, Census information was used to identify any general tendencies for association between first-call outcomes and the Metropolitan status and median income of the geographical areas defined by telephone exchanges. While at best a general measure of urbanicity and income of households associated with sampled telephone numbers, exchange-level demographic data present an opportunity to identify any large differences in data collection efficiencies that may result from demographic differences at the exchange level.

6. Results

The results are presented separately for comparing time cells for the first call attempt and for assessing three-dial call patterns by their efficiency in resolving telephone numbers (as households, non-residential, or out of scope) and in contacting households. Following these results, first-call outcomes are presented by the Metropolitan status and median income of the telephone exchange containing a sampled telephone number.

6.1 Optimal Day of Week/Time of Day Cells for the First Call Attempt

Eighteen time cells, as shown in Exhibit 1, were identified for first-call analyses, excluding some daytime cells that are not commonly used by the NIS for first call attempts.

After the first call attempt, the key rates are 46.8%, 25.0%, and 25.1% for resolution, household contact, and CASRO response, respectively. The mean values for Exhibit 3 are, of course, lower than the final rates obtained on the study since (by definition) there are neither callbacks nor refusal conversion practiced on the first call attempt.

**Exhibit 3: Descriptive Statistics on 18 Time Cells
for First-Call Analyses (Unweighted)**

Statistics	Resolution Rate (%)	HH Contact Rate (%)	CASRO Rate (%)
Mean	46.8	25.0	25.1
Std. Deviation	1.7	3.1	1.8
Range	43.5-49.1	19.7-30.0	20.6-27.6

Note: The results are based on 18 time/day cells. Excluded because of small sample size are 9am-12 noon, Friday noon-6pm, and Sunday 4pm-6pm.

Exhibit 4 lists calling times in descending order of the household contact rate obtained by a first call attempt, also showing the rates for resolution, screener completion, interview completion, and the CASRO rate.

The top-ranked calling times for the household contact rate are Sunday, Monday, Tuesday, and Wednesday evenings (6pm-9pm). Primarily because of small differences in the interview completion rates for the best performing cells, the rank order is different for the CASRO rate. While Sunday evening is a highly efficient for contacting households, the interview completion rate for this time is slightly lower than the rate for Monday-Thursday evenings. Consequently, when measuring optimality by the CASRO rate, Sunday evening is only the third-ranked calling time for placing a first call attempt.

The next tier of CASRO rate performance is found on Monday-Thursday from 4pm-6pm and on Sunday afternoon. The lowest CASRO rate performers are Friday evening, Monday-Thursday afternoons, and late Saturday afternoon.

By ranking calling patterns by various dimensions, Exhibit 4 illustrates the trade-off between optimizing on contact versus response rates for some calling patterns. Sunday afternoon, for instance, is the highest ranked calling time for completing interviews with eligible households. Its last place ranking for resolving cases, however, results in the cell being assigned a middle CASRO rate ranking.

**Exhibit 4: Household Contact and Response Rates for 18 Calling Times,
First-Call Rates in Descending Order of Contact Rate**

Calling Time	Number Fielded	HH Contact Rate	Resolution Rate	Screening Completion	Interview Completion	CASRO Rate
Sunday 6pm-9pm	67,780	30.0%	49.1%	91.0%	60.3%	27.0%
Monday 6pm-9pm	173,061	28.7%	48.9%	91.0%	61.9%	27.6%
Tuesday 6pm-9pm	201,444	28.2%	48.2%	90.8%	61.5%	26.9%
Wednesday 6pm-9pm	152,058	27.7%	47.7%	90.6%	61.9%	26.7%
Thursday 6pm-9pm	167,896	27.2%	47.7%	90.4%	61.0%	26.3%
Saturday 6pm-9pm	75,498	26.8%	46.6%	89.6%	60.4%	25.2%
Sunday 12noon-4pm	13,940	26.2%	43.5%	89.7%	65.7%	25.7%
Friday 6pm-9pm	17,878	25.5%	45.1%	90.7%	59.4%	24.3%
Saturday 4pm-6pm	11,909	25.4%	49.1%	89.1%	47.1%	20.6%
Monday 4pm-6pm	93,834	25.3%	47.6%	89.3%	60.1%	25.6%
Tuesday 4pm-6pm	134,309	25.1%	47.9%	89.3%	62.0%	26.5%
Wednesday 4pm-6pm	114,308	25.0%	47.5%	89.1%	61.6%	26.1%
Thursday 4pm-6pm	68,804	25.0%	47.4%	88.4%	60.9%	25.5%
Saturday 12noon-4pm	11,602	23.9%	46.4%	89.6%	52.2%	21.7%
Monday 12noon-4pm	68,226	20.5%	45.1%	88.3%	59.0%	23.5%
Thursday 12noon-4pm	76,497	20.3%	45.3%	88.8%	59.8%	24.0%
Tuesday 12noon-4pm	121,762	20.0%	44.7%	88.9%	62.5%	24.8%
Wednesday 12noon-4pm	97,492	19.7%	44.9%	88.3%	60.3%	23.9%

Exhibits 5 and 6 are graphical summaries of the household contact and CASRO response rates shown in Exhibit 4. Exhibit 7 identifies the differences between Exhibits 5 and 6 by highlighting calling times where the household and contact rate and CASRO response rates do not have similar ordinal rankings. These intransitive calling times are Tuesday 4-6pm (relatively high CASRO response rate), Friday 6-9pm (relatively low CASRO response rate), and Saturday 4-6pm (relatively low CASRO response rate).

Exhibit 5: Calling Times by First-Call Household Contact Rate (1=Best)

	SUN	MON	TUE	WED	THU	FRI	SAT
12noon-4pm	2	3	3	3	3	N/A	3
4pm-6pm	N/A	2	2	2	2	N/A	2
6pm-9pm	1	1	1	1	1	2	2



Exhibit 6: Calling Times by First-Call CASRO Response Rate (1=Best)

	SUN	MON	TUE	WED	THU	FRI	SAT
12noon-4pm	2	3	3	3	3		3
4pm-6pm		2	1	2	2		3
6pm-9pm	1	1	1	1	1	3	2

Exhibit 7: Contrasting First-Call Household Contact and CASRO Response Rates for Selected Calling Times

Calling Time	HH Contact Rate (%) Mean = 25.0%	CASRO Rate (%) Mean=25.1%
Tuesday 4-6pm	25.1 (rank 11)	26.5 (rank 5)
Friday 6-9pm	26.8 (rank 8)	24.3 (rank 13)
Saturday 4-6pm	25.4 (rank 9)	20.6 (rank 18 of 18)

6.2 Resolution Rates for Three-Dial Call Patterns

Resolving cases as household, non-residential, or out-of-scope is the first component of the CASRO response rate calculation. A three-dial call pattern that is successful in resolving a high percentage of cases by the end of the third dial attempt would be regarded as worthy of further evaluation and possibly incorporation into the CATI call scheduler for RDD studies.

For the 104 three-dial call patterns most common to the NIS (N cases > 1,000 at the third dial attempt), the resolution rate (as described above) was calculated as of the conclusion of the third attempt in a formula that takes into account cases resolved on the first and second attempts (which are then are not dialed additionally for the purpose of resolution). Because data collection costs are also an important consideration, the average number of call attempts required within each three-dial pattern is also calculated. The ratio of resolution rate to the average number of dial attempts for resolving a telephone line is a three-dial pattern's resolution efficiency. This ratio is transformed into a *yield rate*: the number of resolved cases per 100 call attempts for a given call pattern. For example, if the resolution rate is 50% after the sequence of three possible dial attempts, and the average number of dial attempts over the case pattern is 1.5, the resolution efficiency would be .5 / 1.5 or a yield of 33 resolved cases per 100 call attempts. The higher the yield, the more effective a calling pattern is in terms of balancing resolution rate and data collection costs.

As shown in Exhibit 8, the average resolution rate among the selected 104 three-dial call patterns is 66.6%; the range is from 62% to 70%. The average number of call attempts required to resolve a case is 1.61 calls. The mean yield rate is 41 resolved cases per 100 call attempts.

**Exhibit 8: Summary Statistics on 104 Common NIS Three-Dial Call Patterns
(Minimum of 1,000 Dial Attempts at Third Dial Attempt)**

Statistics	N Fielded at 3rd Dial Attempt	Resolution Rate after 3rd Dial Attempt (%)	Mean Number of Dial Attempts
Mean	2,529	66.6	1.61
Std. Dev.	2,468	2	0.039
Range	1,000-16,390	62-70	1.52-1.71

Exhibit 9 displays the resolution rate, the average number of call attempts, and the resolution yield rate for the most efficient three-dial call patterns. While the resolution rate for some three-dial call patterns exceeded 70%, these patterns required slightly more dial attempts to reach these levels. More balanced results are obtained from calling patterns that had slightly lower resolution rates and a lower average number of call attempts.

The most efficient call patterns have a first call attempt on Sunday-Thursday evening (6pm-9pm), followed by a second attempt the morning or afternoon on the next day, and then following by a third attempt the same evening. Call patterns whose first call attempt is in the late afternoon (4pm-6pm) did not perform as well, generally having an efficiency rating about 3 percentage points lower than call patterns whose first call is made on a Sunday through Thursday evening (6pm-9pm).

Three of the top five call patterns involve placement of the second call attempt on Friday mornings. This result is most probably an artifact of the project's interviewer staffing, and should be discounted. Since Friday morning is lightly staffed and relies on the study's more experienced interviewers, there may be an interviewer effect that explains the high resolution rates for call patterns whose second attempts occur on Friday during the day.

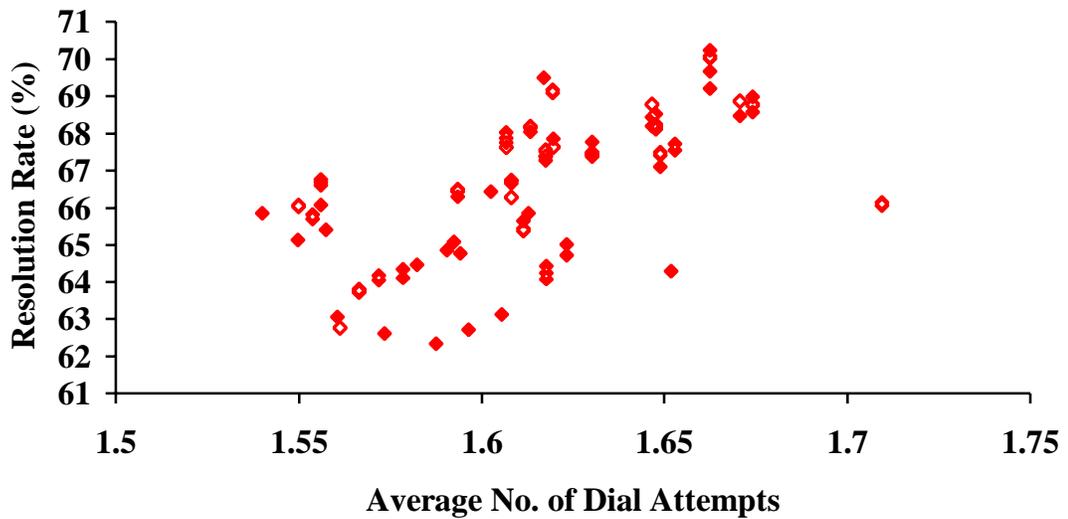
Overall, the underlying dynamic appears to be that the first call attempt in the evening achieves a high contact rate with households; the second dial attempt in the afternoon of the next day is efficient in resolving non-residential telephone numbers; while the third dial attempt in the evening again is an efficient time to obtain contacts with households that were missed on the first two call attempts. Exceptions to this rule are calling patterns whose third attempt is on Saturday morning or afternoon. The results suggest that these are effective times to contact households that could not be reached on Thursday evenings.

Exhibit 9: Top-Ranked Three-Dial Call Patterns, Ranked in Order of Yield (Number of Resolved Cases Per 100 Call Attempts)

Call 1	Call 2	Call 3	N Fielded at 3 rd Dial Attempt	Resolution Rate after 3 rd Dial Attempt	Mean Number of Dial Attempts	Yield (No. of Resolved Cases per 100 Calls)
MON 6p-9p	TUE 4p-6p	TUE 6p-9p	1,000	66.32%	1.52	43.5
SUN 6p-9p	MON 9a-12n	MON 6p-9p	6,189	69.49%	1.62	43.0
THU 6p-9p	FRI 9a-12n	FRI 6p-9p	2,161	66.68%	1.56	42.9
THU 6p-9p	FRI 9a-12n	SAT 9a-12n	2,224	66.76%	1.56	42.9
THU 6p-9p	FRI 9a-12n	SAT 12n-4p	1,172	66.61%	1.56	42.8
TUE 6p-9p	WED 4p-6p	WED 6p-9p	1,780	65.85%	1.54	42.8
SUN 6p-9p	MON 12n-4p	TUE 6p-9p	1,233	69.18%	1.62	42.7
SUN 6p-9p	MON 12n-4p	MON 6p-9p	3,593	69.08%	1.62	42.7
THU 6p-9p	FRI 4p-6p	SAT 12n-4p	1,493	66.03%	1.55	42.6
THU 6p-9p	FRI 4p-6p	SAT 9a-12n	2,368	66.08%	1.55	42.6
TUE 4p-6p	WED 6p-9p	THU 6p-9p	1,705	66.07%	1.56	42.5
WED 6p-9p	THU 4p-6p	SAT 9a-12n	1,552	65.82%	1.55	42.4
WED 6p-9p	THU 4p-6p	SAT 12n-4p	1,105	65.70%	1.55	42.3
MON 6p-9p	TUE 9a-12n	THU 6p-9p	1,415	70.24%	1.66	42.3
MON 6p-9p	TUE 12n-4p	SAT 9a-12n	1,917	68.02%	1.61	42.3
TUE 4p-6p	TUE 6p-9p	WED 6p-9p	2,870	68.19%	1.61	42.3
MON 6p-9p	TUE 9a-12n	SAT 9a-12n	1,504	70.07%	1.66	42.2
MON 6p-9p	TUE 12n-4p	SAT 12n-4p	2,080	67.74%	1.61	42.2
TUE 4p-6p	TUE 6p-9p	WED 9a-12n	2,585	68.15%	1.61	42.2
TUE 4p-6p	TUE 6p-9p	WED 12n-4p	2,842	68.05%	1.61	42.2
MON 6p-9p	TUE 12n-4p	WED 6p-9p	4,218	67.88%	1.61	42.2
MON 6p-9p	TUE 12n-4p	THU 6p-9p	1,504	67.64%	1.61	42.1
MON 6p-9p	TUE 9a-12n	WED 6p-9p	2,524	70.00%	1.66	42.1
MON 6p-9p	TUE 12n-4p	TUE 6p-9p	4,256	67.62%	1.61	42.1
WED 4p-6p	THU 6p-9p	SAT 9a-12n	1,066	65.14%	1.55	42.0
MON 4p-6p	TUE 6p-9p	WED 6p-9p	1,336	65.41%	1.56	42.0

The most and least efficient three-dial calling patterns for resolving RDD sample are visible in Exhibit 10, which graphs the resolution rate of each pattern against the number of call attempts required by the three-dial pattern. The most efficient patterns are in the northwest quadrant, while the least efficient are in the southeast quadrant. Generally, the higher the number of call attempts, the higher the obtained resolution rate. The more efficient patterns, however, provide a better balance by economizing on the number of call attempts required to obtain a similarly high resolution rate.

Exhibit 10: Resolution Rate by Average Number of Call Attempts in Three-Dial Call Patterns



6.3 Household Contact Rates for Three-Dial Call Patterns

A total of 122 three-dial calling patterns qualified as common NIS patterns for the purpose of ranking patterns by their efficacy in obtaining a contact with an adult householder. For these common patterns, a mean household contact rate of 38.4% was obtained after the third call attempt, requiring an average of 1.66 dial attempts to obtain this result. Compared to the results reported above on resolution rates, there is more variance in the household contact rates obtained by the various calling patterns. The lowest household contact rate is 33.0% compared to a high of 44.2% after the third call attempt, as shown in Exhibit 11.

Exhibit 11: Summary Household Contact Statistics on 122 Common NIS Three-Dial Call Patterns (Minimum of 1,000 Dial Attempts at Third Dial Attempt)

Statistics	HH Contact Rate after 3rd Dial Attempt (%)	Mean Number of Dial Attempts
Mean	38.4%	1.66
Std. Dev.	2.7%	0.04
Range	33.0-44.2%	1.57-1.77

Exhibit 12 displays the five most efficient three-dial calling patterns for contacting households. The dominant pattern is a Sunday evening or Monday-Wednesday evening call attempt, followed by a second attempt in the late afternoon of the next day, and then followed by a third call attempt the same evening. These patterns resulted in household contact rates 3 or more percentage points higher than the mean obtained for the 122 common NIS calling patterns.

Exhibit 12: Top Five Three-Dial Call Patterns, Ranked in Order of Household Contact Yield (Number of Household Contacts Per 100 Call Attempts Required by Calling Pattern)

Call 1	Call 2	Call 3	N Fielded at 3rd Dial Attempt	HH Contact Rate after 3rd Dial Attempt (%)	Yield (No. of HH Contacts Per 100 Calls)
MON 6p-9p	TUE 4p-6p	TUE 6p-9p	1357	43.9	27.9
SUN 6p-9p	MON 4p-6p	MON 6p-9p	1054	44.2	27.7
TUE 6p-9p	WED 4p-6p	WED 6p-9p	2180	42.1	26.5
TUE 6p-9p	WED 4p-6p	THU 6p-9p	1130	41.8	26.3
WED 6p-9p	THU 4p-6p	THU 6p-9p	1192	41.5	25.9

6.4 Optimal Day of Week/Time of Day Cells by Metropolitan Status and Median Income of Telephone Exchange

Household contact rates obtained after one call attempt may be analyzed by proxy variables for urbanicity and income: the metropolitan status and median income (updated 1990 Census data) of the zip codes that map to the telephone exchange for the sample telephone number.

Because the CATI call scheduler does not routinely field first-time-in cases on Fridays and the weekends, there was inadequate sample for this analysis for these days for relatively rare groups: telephone numbers in exchanges whose median income is less than \$15,000 a year or more than \$75,000 a year.

As shown in Exhibit 13, the data suggest that non-MSA, followed by non Central City areas of MSAs, have the highest overall first-call contact rates—28.3% and 26.7%, respectively. Central Cities of MSAs have a lower contact rate of 23.1%. For Monday-Thursday, the pattern is for the household contact rate to increase steadily from morning onwards through evening (from 18.2% to 28.0%). This tendency is evident for each MSA type. The pattern for Saturday and Sunday is more U-shaped, with a higher contact rate in the morning followed by lower rates in the afternoon, and then the highest rate in the evening. Exhibits 14 and 15 show graphically the patterns for Monday-Thursday and the weekends, respectively.

Exhibit 13: First-Call Household Contact Rates by Metropolitan Status

	Center City of MSA	MSA, Not in Center City	Not an MSA	Row Average
N Fielded	787,794	542,829	372,471	
Mon-Thurs				
9-12noon	16.6%	19.0%	20.1%	18.2%
12-4pm	18.4%	20.8%	22.7%	20.1%
4-6pm	22.5%	26.6%	28.5%	25.1%
6-9pm	25.6%	29.5%	30.8%	28.0%
Friday				
9-4pm	19.4%	21.9%	23.2%	21.0%
4-9pm	23.1%	27.1%	27.4%	25.3%
Sat/Sun				
9-12noon	26.4%	28.8%	27.1%	27.3%
12-4pm	22.8%	27.8%	26.7%	25.2%
4-6pm	23.9%	28.2%	25.3%	25.4%
6-9pm	26.0%	29.7%	31.2%	28.3%
Column Average	23.1%	26.7%	28.3%	25.4%

Exhibit 14: Monday-Thursday First-Call Household Contact Rates by Metropolitan Status

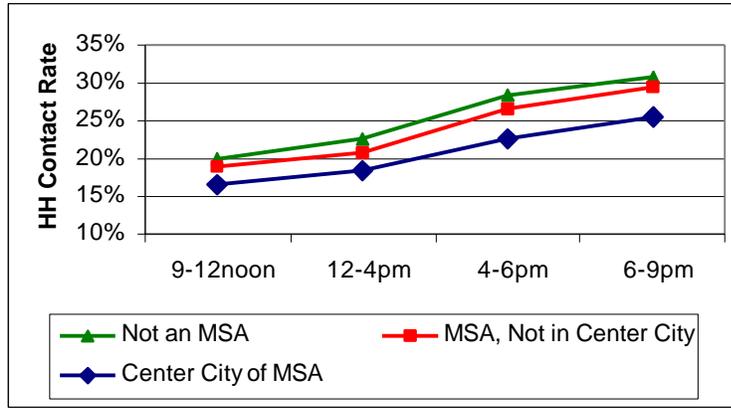
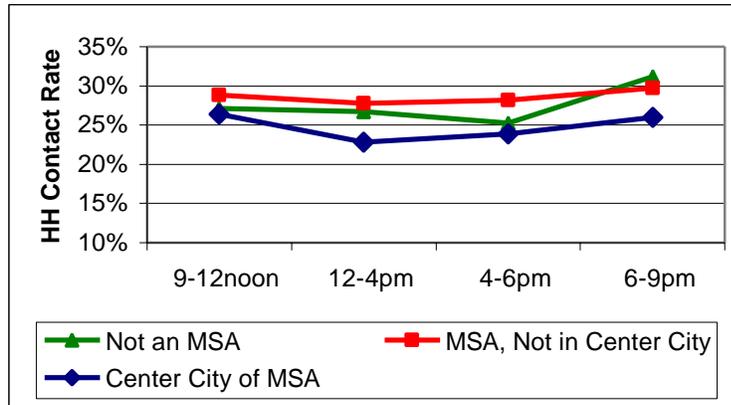


Exhibit 15: Saturday-Sunday First-Call Household Contact Rates by Metropolitan Status



The median income data, as shown in Exhibits 16 and 17, are suggestive that both ends of the income spectrum are the most difficult to contact. First-call household contact rates are 18.2% for exchanges with a median income of less than \$15,000, and are 22.8% and 21.3% for areas having a median income of \$50,000-\$75,000 and \$75,000 and over, respectively. Areas having a median income of \$25,000-\$35,000 have the highest household contact rate at 27.1%. Contacting households in high-income areas appears to have the highest probability of success on weekday mornings and evenings, as shown in Exhibit 18.

Exhibit 16: First-Call Household Contact Rates by Median Income of Telephone Exchange Area⁶

	\$0-\$15K	\$15K-\$25K	\$25K-\$35K	\$35K-\$50K	\$50K-\$75K	\$75K+
N Fielded	12,708	266,935	607,378	590,591	211,537	13,945
Mon-Thurs						
9-12am	10.2%	17.4%	20.7%	17.3%	16.7%	22.0%
12-4pm	16.1%	20.3%	21.9%	19.4%	17.0%	16.4%
4-6pm	18.0%	24.2%	26.8%	25.1%	21.9%	19.9%
6-9pm	19.3%	25.8%	29.6%	28.3%	26.0%	23.7%
Friday						
9-4pm	N/A	20.1%	23.5%	20.6%	18.1%	N/A
4-9pm	N/A	23.4%	27.4%	25.4%	22.3%	N/A
Sat/Sun						
9-12am	N/A	26.5%	29.2%	26.1%	26.5%	N/A
12-4pm	N/A	22.8%	26.6%	24.9%	25.4%	N/A
4-6pm	N/A	23.6%	27.1%	25.3%	24.0%	N/A
6-9pm	N/A	26.5%	30.1%	28.4%	25.5%	N/A
Average	18.2%	24.1%	27.1%	25.4%	22.8%	21.3%

⁶ There was inadequate sample size for the Friday and Saturday/Sunday cells; the column average, however, does take into account the cases in these cells.

Exhibit 17: First-Call Household Contact Rates by Median Income of Telephone Exchange

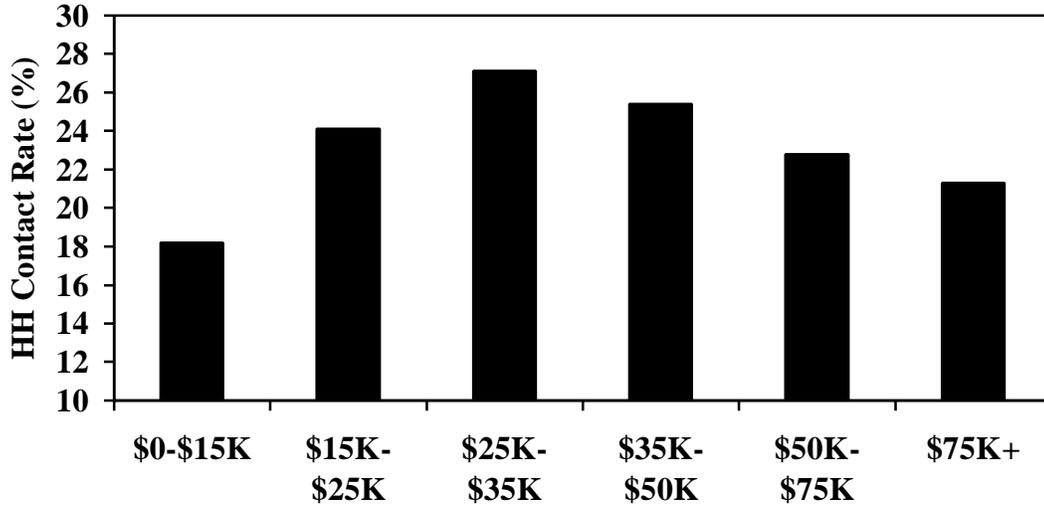
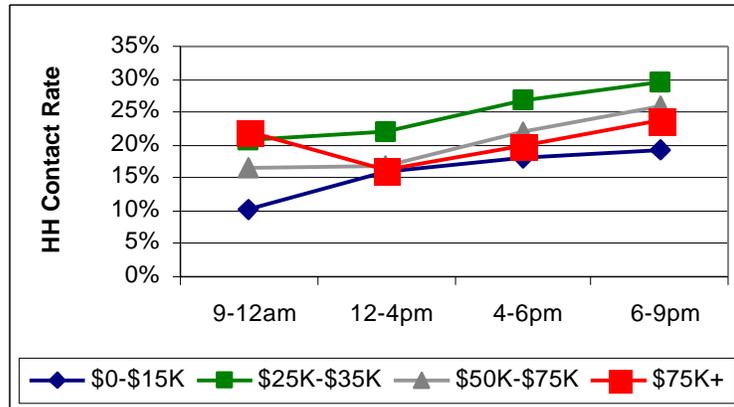


Exhibit 18: Monday-Thursday First-Call Household Contact Rates by Selected Median Income Exchanges



7. Discussion of Results

The research suggests that the first call attempt for RDD surveys should be placed on Sunday-Thursday evenings between 6pm and 9pm (respondent local time). A RDD study using a single-call approach and following this schedule would be expected to have a household contact rate of approximately 28% and a CASRO response rate of approximately 26%, assuming data collection procedures, instrumentation, and staffing are comparable to those employed by the NIS. Placing the first call attempt on weekend afternoons or on weekdays between 4pm and 6pm results in a decrease of approximately 3 percentage points for the contact rate and 1-2 percentage points for the CASRO rate. These rate differences, when multiplied over hundreds of thousands of sampled telephone numbers, may be viewed as large enough to warrant refinements of the CATI call scheduler and the scheduling of interviewers.

The analyses of three-dial call patterns focus on the efficiency of resolving cases as residential, non-residential, or out of scope as well as the efficiency of contacting households. From the perspective of maximizing resolution efficiency, most of the optimal three-dial call patterns have in common these traits:

- Placement of the first call attempt on Sunday-Thursday evenings (6pm-9pm);
- Placement of the second call attempt on the following afternoon;
- Placement of the third call attempt the evening of the second dial attempt.

There are nuances to this pattern to be observed. For instance, if the first call attempt occurs on a Thursday evening, placement of the third call on Saturday morning or afternoon is an efficient alternative to placing the third call attempt on Friday evening. There also appears to be a slight advantage in placing the second call attempt on a weekday between 4pm and 6pm.

Counter to our preliminary expectations, calling patterns based on two or three consecutive weekday evening dial attempts were outperformed by calling patterns having an afternoon or late afternoon dial attempt on the second or third dial attempt. This is consistent with Kulka and Weeks' work using a conditional probability approach (1988). This finding is supported by inspection of relatively rare calling patterns (e.g., third call attempt has fewer than 500 dial attempts). Placing an afternoon or late afternoon call attempt on the second or third attempt or, alternatively, placing such call attempts on weekend afternoons or weekends, is shown to be an effective strategy for resolving telephone sample.

First-call household contact rates vary by Metropolitan status. A higher proportion of sampled telephone lines is successfully contacted on the first call attempt in nonMSA areas, with the lowest contact rate belonging to the Central Cities of MSAs. The general tendency for efficient dialing on weekday evenings and weekends apply across the MSA/non-MSA groups. There are no clear, counter-intuitive tendencies that suggest, for example, that there is an advantage in calling Central City areas on weekend mornings compared to weekend evenings.

Similar findings apply to the median income of the exchange. Exchanges with a median annual

income of less than \$15,000 have the lowest first-call contact rate at 18.2%, compared to a high of 27.1% for areas in the range of \$25,000-\$35,000. A finding worthy of further investigation is the relative success of contacting households in high median income exchanges on Monday-Thursday mornings.

8. Conclusions

Because of the large volume of call attempts made in the NIS, relatively small changes in the CATI call scheduler have the potential to increase substantially the efficiency of the study. By patterning the first few call attempts according to algorithms informed by the above analyses, study researchers are attempting to minimize the number of call attempts required to have an adult respondent answer the phone and then complete the eligibility screen and, if appropriate, the interview. A CATI call scheduler based on analyses of calling patterns has the potential to reduce the costs of an RDD survey without compromising the response rate.

The next phase of the research involves aggregating the electronic record of calls and sample frame data across additional data collection years in order to assess longitudinal trends in RDD contact and response rates, to identify any seasonality effects, and to allow for sufficient sample size for identifying five-dial optimal calling patterns.

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