Optimum Calling Patterns for Random Digit Dialed Telephone Surveys

James T. Massey, National Center for Health Statistics, CDC
Charles Wolter, Siu Chong Wan, Karen Liu, Klemm Analysis Group, Inc
James T. Massey, 7734 Bridle Path Lane, McLean,VA 22102

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1. Introduction

In recent years, changes in technology have continued to increase the efficiency of computer assisted telephone interviewing (CATI) systems. Sample telephone numbers can be delivered to interviewers more efficiently, and interviewers have greater control in their interaction with the respondent and the CATI questionnaire screens. There is greater flexibility in the development and maintenance of data base management systems containing sample control information and interview data. New techniques in list-assisted random digit dialing (RDD) sample selection have also helped to decrease the costs of telephone surveys.

Despite all these improvements in the CATI process, a substantial portion of the survey resources must be spent attempting to contact a respondent at a residential address and eventually obtaining an interview. The effort to achieve this task can be lessened if one can determine those times which are optimum for making contact with respondents. An optimal calling pattern will maximize the likelihood of making contact with a household with a sequence of calls thereby reducing survey costs and shortening the interviewing period. Minimizing the number of calls to reach households in a sample of randomly selected telephone numbers is even more critical in a survey that requires a screening questionnaire to identify eligible in-scope households.

Most of the earlier research on call scheduling focused on the optimum time of day and day of week to make a contact on the first dialing of a telephone number. Kulka and Weeks(1988) extended this area of research by studying the optimal timing of second calls to telephone numbers that were not answered on the first call. Kulka and Weeks used a conditional probability approach to evaluate call scheduling patterns. The conditional approach recognizes that the probability of a specific call outcome for a telephone number is dependent on the timings of the previous calls to the number. To compute the probability of making a first contact on a particular call to a telephone number, for example, the conditional probability of not making a household contact on earlier calls to this number must be determined. Kulka and Weeks(1988) examined a number of three call patterns to identify call patterns that had the highest overall contact rate.

This paper extends the work of Kulka and Weeks by examining the proportion of households that are contacted with one, three and five call patterns. For the three and five call patterns, both the likelihood of contacting households and the likelihood of contacting households and businesses are examined. For this paper calling patterns are evaluated in terms of making human household contact. Answering machine contacts and ring no answers are both treated as non-household contacts. The paper also examines some of the household and non-household outcomes for the one and three call patterns. The outcome categories shown in this paper are nonworkings/businesses, ring no answers, answer machines, refusals/breakoffs/callbacks and completed screening household interviews. The call patterns were ranked according to number of dialings and contact rates. The interview completion status of a household contact was not used in the ranking of the calling patterns.

2. Methods

Data from the National Immunization Survey(NIS) was used to evaluate calling patterns shown in this paper. The NIS is a large RDD telephone survey conducted by Abt Associates Inc. for the Center for Disease Control and Prevention(CDC) in 78 separate areas covering the entire United States. A screening interview is used to identify households with children between the age of 19-35 months. The most knowledgeable adult in each of these households is then interviewed about the child's immunization history. The extensive screening required in NIS to identify households with two year olds provides a unique opportunity to evaluate telephone calling patterns in more detail. A total of over 1.5 million numbers were dialed by Abt during 1995. Calls were made from 9a.m. to 9p.m. respondent time every day of the week. The minimum sample size for any hour interval for first calls was 3354 on Friday from 9a.m-10a.m.. The time intervals used to evaluate the call pattern sequences were formed by collapsing hourly time intervals that had similar household contact rates.

The sample of randomly selected telephone numbers for the NIS was generated using the AT&T master list of prefix areas to identify all area codes and exchanges.

The sample of numbers was prescreened for nonworking and known business numbers. Directory listings were also used to delete banks of numbers with zero directory listings. The 1994 and 1995 NIS final dialing results indicate that approximately 60 percent of the telephone numbers dialed were residential household numbers.

By knowing the expected number of households in the sample one can estimate the proportion of households that are contacted for any given calling pattern. For each call made in a calling pattern, one can estimate the contact probability of making the first human contact using the NIS data. The probability for each call in the calling pattern are summed and then divided by the proportion of numbers that are households. A similar calculation is made for contacting a household or business.

3. Results

Table 1 presents the percentage of households that are contacted on the first call. For example, for first calls made between 9a.m and 10 a.m. on Monday, 52 percent of the households in the sample would be reached. Table 1 confirms what other research has already shown. For first calls, one reaches a higher proportion of households on weekday nights, a lower proportion of households are reached from mid-morning to early afternoon on weekdays, and a reasonably high proportion of households can be reached at any time on Saturday and Sunday.

Table 2 shows the distribution of first call outcomes by time of day and day of week. As one might expect refusals and other pending cases (breakoffs, appointments, callbacks) are higher at night and on weekends. Unfortunately, these are the best times to reach sample persons. There is clearly a trade-off between the best times to contact households and best times to gain a respondent's cooperation.

Table 3 presents the results of three call patterns. The patterns are ranked by household contact, household or business contact, and number of dialings. The sum of the 3 rankings is used to order the patterns shown in Table 3. Approximately 86 percent of households can be reached in 3 calls using the best calling patterns. In general, the best calling patterns have two or more calls on weekends, early evenings, and nights. The poorest performing patterns have two or more weekday calls.

Table 4 looks at selected outcomes for the three call patterns. For the three call patterns, the best patterns in terms of contact are only slightly worse in terms of refusals, breakoffs, and callbacks. The difference between the best and worse contact patterns are only a couple of percentage points different for refusals, other

pending cases, and households with completed screening interviews. Further analysis shows that refusals and other pending outcomes (breakoffs/ appointments/ callbacks) have a high negative correlation. When these two categories are combined, there are only small difference between any of the three call patterns.

Table 5 presents the results for the 50 best overall five call patterns. A total of 684 five call patterns were analyzed, but could not be shown because of space limitations. The best five call patterns reach approximately 90 percent of households in the survey. In contrast, the worst five call pattern, DDDDD, reaches 75 percent of the households in the sample and requires 15 percent more dialings. One common feather among the 50 best patterns is that none of them contain more than one daytime weekday dialing.

4. Discussion

Because of space limitations, a number of research results could not be shown. One finding not shown is that call patterns that are best for reaching ring no answers(RNA) are also best for reaching answering machines(AM). Human contacts for previous AM outcomes, however, are reached at a much faster rate than the RNA. A general conclusion reached about call scheduling is that the best patterns for household contact have a predominant mix of weeknight and weekend calls. Having a single daytime call among the first five calls is advisable, preferably among the first 3 calls. The weekday calls are better at reaching businesses and result in fewer refusals and breakoffs, but only slightly. There appears to be a wide range of good patterns to choose from, or stated in another way, avoid patterns with a significant percentage of weekday daytime calls.

The relative efficiency of the best call patterns versus those not so good cannot be adequently evaluated with the results shown in this paper. To study efficiency, one needs to fix either the percent of households (or households/businesses) contacted or the number of dialings. This is best accomplished by contrasting call patterns with different number of calls. For example, the five call patterns that contact the same percent of households that the best of the three call patterns contact, require approximately 22 percent dialings. It does appear that good call scheduling and proper distribution of interviews across shifts can be an effective method to help control the cost of telephone interviewing. There are, however, many other factors that determine the overall efficiency of a well managed RDD data collection operation that were not discussed in this paper.

5. References

Kulka, R.A. and Weeks, M.F. (1988): Toward the Development of Optimal Calling Protocols for Telephone Surveys: A Conditional Probabilities Approach. Journal of Official Statistics, Vol 4. No 4, pp.319-332.

Table 1. Percent of Households That Answer First Call by Time of Day and Day of Week

Time of Day	Day of Week						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
9am-10am	52.0	48.3	49.0	48.6	49.3	60.7	66.7
10am-11am	43.4	40.2	41.6	40.8	43.0	59.3	59.2
11am-12pm	42.2	39.4	41.2	40.4	42.9	55.5	54.3
12pm-1pm	42.5	40.3	42.4	40.8	42.7	54.1	54.2
1pm-2pm	43.5	40.0	40.1	40.5	41.6	53.5	55.4
2pm-3pm	41.1	42.5	41.7	42.9	42.9	52.6	54.1
3pm-4pm	43.2	46.0	44.6	44.5	45.6	52.8	54.4
4pm-5pm	51.6	52.9	50.4	49.2	51.6	54.5	55.9
5pm-6pm	58.1	56.5	58.0	56.4	56.2	57.3	57.0
6pm-7pm	59.9	58.3	60.4	59.1	56.3	55.4	58.4
7pm-8pm	61.1	60.9	59.5	58.8	53.9	57.1	62.1
8pm-9pm	65.5	65.3	63.4	64.6	56.9	60.7	66.6

Note: Answer machine is considered unanswered telephone number.

Table 2.   Outcomes of First Calls by Time of Day and Day of Week (Percent)

Outcome by Time of Day	Day of Week						
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Nonworkings/Businesses							
9am-12pm	31.5	31.7	31.6	31.3	29.8	25.4	26.6
12pm-3pm	32.4	32.9	31.0	31.3	30.4	26.3	26.8
3pm-6pm	30.8	30.3	29.8	30.3	28.8	25.9	27.4
6pm-9pm	28.0	28.1	27.4	27.6	27.2	25.7	27.2
Ring No Answers							
9am-12pm	23.5	24.3	24.2	23.4	24.1	24.6	24.6
12pm-3pm	23.0	23.2	24.5	24.1	24.3	25.4	25.3
3pm-6pm	22.7	22.3	23.1	23.1	23.8	25.3	24.8
6pm-9pm	22.8	22.9	23.6	23.2	24.4	25.2	23.3
Answer Machines							
9am-12pm	18.6	19.4	18.8	20.5	20.0	15.5	14.3
12pm-3pm	19.2	19.5	19.6	19.9	19.8	16.2	15.2
3pm-6pm	15.3	15.6	15.7	16.0	15.8	15.6	14.3
6pm-9pm	11.8	12.0	12.3	12.5	15.0	14.7	11.8
Refusals/Breakoffs/Callbacks							
9am-12pm	6.6	6.6	6.4	6.6	7.0	9.6	9.8
12pm-3pm	6.8	6.9	6.4	6.4	6.7	8.6	9.0
3pm-6pm	8.9	8.9	8.9	8.4	8.7	9.4	9.3
6pm-9pm	10.3	10.1	10.2	10.2	9.6	10.4	10.3
Completed Screening Interviews							
9am-12pm	19.8	18.0	19.0	18.2	19.1	25.0	24.7
12pm-3pm	18.7	17.6	18.5	18.4	18.7	23.5	23.7
3pm-6pm	22.5	22.9	22.6	22.2	23.0	23.7	24.2
6pm-9pm	27.1	26.9	26.5	26.5	23.9	24.0	27.4

Table 3. *Percent of Households and Businesses Contacted on First Three Calls*

(D: 9am-3pm M-F / T: 3pm-6pm M-F / N: 6pm-9pm M-F / W: Weekend)

Calling Pattern	Overall* Rank	Percent of HH Contacted	Rank For (3)	Percent of HH/Business Contacted	Rank For (5)	Average Dials** Per Number	Rank For (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
WTN	1	86.1	2	84.7	1	1.78	20
WNT	2	85.1	5	84.0	3	1.78	21
TNW	3	84.2	10	83.1	6	1.76	14
NNT	4	83.6	13	82.2	16	1.74	2
NTN	5	83.1	15	82.2	19	1.74	1
NND	6	82.6	20	82.4	14	1.74	3
WND	7	83.6	12	84.0	4	1.78	23
WDN	8	83.7	11	84.3	2	1.80	30
TWN	9	83.1	16	82.6	10	1.78	22
WNN	10	86.0	3	82.2	18	1.79	28
NTW	11	82.4	21	81.6	26	1.75	4
NNW	12.5	84.9	6	80.9	37	1.75	9
NWD	12.5	81.9	25	82.3	15	1.76	12
NDN	14	81.6	27	82.1	22	1.75	5
NWT	15.5	83.0	18	81.6	25	1.76	13
WWT	15.5	84.4	8	82.6	8	1.82	40
TNN	17	83.1	17	82.0	23	1.77	17
NWN	18	84.7	7	81.0	35	1.77	16
WTT	19	82.3	22	82.6	9	1.80	29
NDW	20.5	81.3	30	81.9	24	1.75	8
NNN	20.5	84.3	9	80.4	43	1.76	10
DNN	23	82.3	23	83.2	5	1.81	36
TTN	23	81.8	26	82.4	13	1.78	25
WWN	23	86.3	1	82.1	21	1.82	42
WWD	25	82.9	19	82.9	7	1.82	39
TNT	26	81.3	29	81.5	29	1.77	18
DNW	27	81.6	28	82.5	11	1.82	38
NTT	28.5	80.6	34	80.9	39	1.75	7
WDT	28.5	80.9	31	82.5	12	1.81	37
NTD	30	79.7	41	81.0	34	1.75	6
NDT	31.5	80.0	39	81.1	33	1.76	11
TWW	31.5	81.9	24	81.1	32	1.79	27
TND	33	80.1	38	81.1	31	1.78	19
NWW	34	83.2	14	79.2	52	1.78	24
WWW	35	85.6	4	80.6	41	1.84	46
WTD	36	80.4	36	81.5	27	1.81	34
DTN	37.5	80.6	33	82.2	17	1.85	50
DWN	37.5	80.8	32	82.2	20	1.84	48
TWT	39	80.5	35	81.0	36	1.80	31
TTW	40	79.9	40	80.9	38	1.79	26
NDD	41	77.9	47	79.8	46	1.77	15
DNT	42	79.5	42	81.3	30	1.82	43
DWW	43	80.2	37	81.5	28	1.85	51
TWD	44	78.7	44	80.5	42	1.80	32
TDN	45	79.0	43	80.8	40	1.82	41
TTT	46	77.5	49	79.3	51	1.80	33
TDW	47	77.8	48	79.7	48	1.83	44
WDD	48	77.4	50	79.7	47	1.83	45
DTW	50	78.5	45	80.3	44	1.86	54
DWT	50	78.1	46	80.0	45	1.86	52
TTD	50	76.0	54	78.5	54	1.81	35
DND	52	77.1	51	79.4	50	1.84	47
DDN	53	76.9	52	79.6	49	1.91	58
DTT	54.5	76.7	53	79.1	53	1.87	55
TDT	54.5	75.1	56	77.5	56	1.84	49
DWD	56	75.3	55	78.0	55	1.87	56
DDW	58	74.3	57	77.4	57	1.93	59
DTD	58	73.2	58	76.4	58	1.89	57
TDD	58	72.0	60	75.1	60	1.86	53
DDT	60	72.5	59	76.0	59	1.94	60
DDD	61	66.3	61	70.8	61	1.97	61

* Overall rank is based on the sum of individual ranks (4)+(6)+(8).
** Numerator includes noncontacted numbers after three call attempts.

Table 4. *Selected Outcomes For Three Call Patterns based on Initial Household Contacts (HHC) on First Three Calls*

(D: 9am-3pm M-F / T: 3pm-6pm M-F / N: 6pm-9pm M-F / W: Weekend)

Calling Pattern	% Completed screening Interview on HHC for First 3 Calls	% Refusal on HHC for First 3 Calls	% Breakoff/Callback/ Appointment/Language Barrier on HHC for First 3 Calls	% Refusal/Pendings on HHC for First 3 Calls
	(1)	(2)	(3)	(4)=(2)+(3)
WTN	72.8	12.8	14.4	27.2
WNT	72.5	13.6	13.9	27.5
TNW	73.0	11.9	15.1	27.0
NNT	72.7	13.7	13.6	27.3
NTN	72.5	13.6	14.0	27.5
NND	72.6	13.6	13.8	27.4
WND	72.6	13.5	14.0	27.4
WDN	73.1	12.9	14.0	26.9
TWN	73.1	11.8	15.1	26.9
WNN	72.6	13.5	13.9	27.4
NTW	72.4	13.4	14.2	27.6
NNW	72.7	13.8	13.6	27.3
NWD	72.3	13.7	14.0	27.7
NDN	72.5	13.5	14.0	27.5
NWT	72.0	13.7	14.3	28.0
WWT	72.5	13.8	13.7	27.5
TNN	73.5	11.8	14.6	26.5
NWN	72.1	13.9	14.0	27.9
WTT	72.4	13.1	14.5	27.6
NDW	72.4	13.4	14.1	27.6
NNN	72.5	13.8	13.7	27.5
DNN	73.8	11.7	14.5	26.2
TTN	73.1	11.8	15.1	26.9
WWN	72.5	13.9	13.5	27.5
WWD	72.6	13.6	13.7	27.4
TNT	73.0	12.0	15.0	27.0
DNW	73.7	11.6	14.6	26.3
NTT	72.5	13.1	14.4	27.5
WDT	72.7	12.9	14.5	27.3
NTD	72.4	13.3	14.2	27.6
NDT	72.4	13.2	14.3	27.6
TWW	72.7	12.1	15.1	27.3
TND	73.0	11.9	15.1	27.0
NWW	72.4	13.7	13.9	27.6
WWW	72.5	14.0	13.5	27.5
WTD	72.4	13.0	14.6	27.6
DTN	74.0	11.3	14.8	26.0
DWN	74.0	11.3	14.7	26.0
TWT	72.6	11.9	15.5	27.4
TTW	72.9	11.7	15.4	27.1
NDD	72.3	13.3	14.4	27.7
DNT	74.1	11.3	14.6	25.9
DWW	73.9	11.6	14.5	26.1
TWD	72.5	11.9	15.6	27.5
TDN	73.1	11.7	15.2	26.9
TTT	73.3	11.1	15.7	26.7
TDW	72.7	11.7	15.6	27.3
WDD	72.8	12.9	14.3	27.2
DTW	73.7	11.2	15.1	26.3
DWT	73.8	11.1	15.1	26.2
TTD	73.1	11.2	15.6	26.9
DND	74.0	11.3	14.7	26.0
DDN	74.2	10.9	14.9	25.8
DTT	74.5	10.4	15.1	25.5
TDT	72.7	11.3	16.0	27.3
DWD	73.7	11.2	15.1	26.3
DDW	73.7	11.1	15.2	26.3
DTD	74.1	10.4	15.5	25.9
TDD	72.4	11.5	16.1	27.6
DDT	73.8	10.5	15.7	26.2
DDD	73.9	10.5	15.7	26.1

Table 5. **Percent of Households and Businesses Contacted for 50 Best Calling Patterns on First Five Calls**

(Exclude Patterns With Nonsequential Weekend Calls or # of D>=3 or # of W>=4)
(D: 9am-3pm M-F / T: 3pm-6pm M-F / N: 6pm-9pm M-F / W: Weekend)

Calling Pattern	Overall* Rank	Percent of HH Contacted	Rank For (3)	Percent of HH/Business Contacted	Rank For (5)	Average Dials** Per Number	Rank For (7)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
NNDWN	1	91.4	27	90.5	40	1.96	2
NWNTT	2	93.0	2	90.9	19	1.98	75
TNTTN	3	92.5	4	91.9	3	1.99	124
TNWDN	4	90.8	51	90.7	28	1.98	64
TNWNT	5	90.3	94	91.7	6	1.98	48
NNWND	6	91.5	19	90.1	77	1.98	63
WTNNT	7	92.3	8	90.6	35	1.99	120
WTNND	8	91.6	17	90.9	20	1.99	138
NTWDT	9	90.3	92	90.3	57	1.97	28
TNWWD	10	90.5	74	90.8	23	1.98	86
TTNNW	11	91.1	36	90.4	49	1.99	106.5
NNNTW	12	90.5	77	89.7	115	1.97	10
WNTDT	13.5	90.9	48	91.9	4	2.00	151
WTTNT	13.5	93.7	1	92.9	1	2.00	201
NNWDT	15	90.8	61	89.8	106	1.97	38
WNNTT	16	91.7	13	91.2	13	2.00	194
NTNWN	17	91.1	38	89.3	176	1.97	16
TTTTN	18	91.9	10	92.6	2	2.01	219
TNWWN	19	91.6	14	89.9	87	1.99	130.5
WTNDT	20	91.0	41	90.7	26	2.00	173.5
NDWNN	21	90.1	113	89.8	107	1.97	27
WNNDT	22	91.4	26	91.0	17	2.01	209
WTNNN	23	91.9	12	90.1	71	2.00	170
NNTTD	24	90.4	83	89.3	171	1.96	5
NNTWD	25	89.9	140	89.6	127	1.96	3
WTNDN	26	91.2	32	90.4	46	2.00	198
NNWTN	27	91.0	44	89.3	172	1.98	65
NNTWT	28.5	90.6	73	89.1	204	1.97	13
WTTNN	28.5	92.5	3	91.4	9	2.02	278
TTWNN	30	90.3	93	90.6	33	2.00	166
DNWNN	31	91.5	20	91.4	7	2.02	266.5
WTTTN	32	91.6	15	91.4	8	2.02	271
WNTTN	33	91.6	18	90.6	34	2.01	246
NDWTN	34	89.7	157	89.8	99	1.97	44
NNTTT	35	90.4	88	89.2	186	1.97	29.5
WNNDN	36	91.1	39	90.7	27	2.01	239
NTWND	37	89.4	193	89.8	94	1.97	18.5
NNDWT	38	89.8	148	89.5	151	1.96	9
NNNDT	39	90.0	121	89.4	158	1.97	32
NNTNT	40	89.8	145	89.4	156	1.97	12
NTTWN	41	90.4	82	89.4	163	1.98	69
NNTTW	42	90.8	60	89.0	231	1.97	25
NTDTN	43.5	89.3	203	90.2	67	1.98	49
TNTTW	43.5	90.6	72	90.3	55	2.00	192
WNTDN	45	90.2	108	90.6	29	2.00	186
TTNNN	46	90.3	102	90.0	83	1.99	142
NTTWT	47	90.1	117	89.5	140	1.98	79
NNNDW	48	89.8	149	89.5	153	1.97	39
WDTNN	49	91.2	29	91.9	5	2.02	308
NWNDT	50	89.9	131	89.7	124	1.98	89

* Overall rank is based on the sum of individual ranks (4)+(6)+(8).
** Numerator includes noncontacted numbers after five call attempts.