Purging Out-Of-Scope And Cellular Telephone Numbers From RDD Samples

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Out-Of-Scope Telephone Numbers In Random-Digit-Dialing Samples

List-assisted random-digit dialing (RDD) divides the sampling frame of telephone numbers into banks of 100 consecutive telephone numbers (e.g., 617-349-0000 to 617-349-0099) and removes banks with no residential directory-listed telephone numbers (Casady and Lepkowski 1993). A random sample of 10-digit telephone numbers is then drawn from the frame of "1+ working" banks, that is, banks containing from 1 to 100 residential directory-listed residential telephone numbers. Current RDD sample designs typically limit the resulting sample of households to those with voice-use landline telephones, that is, cellular telephone numbers are treated as out-of-scope telephone numbers.

To understand the structure of RDD samples, we need to discuss the classification of Numbering Plan Areas/Central Office codes (NPA-NNX's), which we shall refer to as telephone exchanges. A telephone exchange consists of an area code and a prefix area within that area code (e.g., 617-349). Each telephone exchange consists of 10,000 telephone numbers. As discussed later we can also view each exchange as consisting of ten 1,000 banks (e.g., 617-349-0000 to 617-349-0999). Telcordia (formerly Bellcore) classifies telephone exchanges into close to thirty categories. For surveys of households there are three relevant categories: 1) land-line service (referred to as Regular or plain old telephone service (POTS)), 2) cellular service, and 3) mixed-use service (e.g., shared between POTS and cellular service). Exchanges in the first and third categories are typically used to create the sampling frame for current RDD samples that only sample households with voice-use landline service. Furthermore, each telephone number in the frame can be classified as residential directory-listed versus not residential directory-listed.

Based on the definition of the list-assisted frame, RDD samples will include numbers that are not voice-use residential landline telephone numbers. By residential voice-use numbers we mean dedicated residential voice-use numbers, dual-purpose residential numbers (e.g., used for computer modem and for voice purposes), and dual-use residential numbers (e.g., numbers used for residential voice and also for business use). We refer to the numbers in the frame that do not fall into these categories as out-of-scope telephone numbers. They consist of nonworking (unassigned) telephone numbers, nonresidential telephone numbers (e.g., business numbers), residential numbers only used for non-voice purposes (e.g., a facsimile machine), and cellular telephone numbers, which can either be business numbers, residential numbers or used for both purposes.

The largest category of out-of scope telephone numbers in RDD samples, and in some ways the most troublesome, is nonworking numbers. We are all aware of the large number of new area codes that have been introduced in the U.S. Tucker, Lepkowski and Piekarski (2002) found that the percentage of 100 banks that contained one or more residential listed numbers declined from 38% in 1990 to 30% in 1999. They also found a decline in the density of residential listed numbers within 100 banks with one or more residential listed numbers – in 1990 close to 15% had 50 or more listed numbers, but by 1999 this had declined to only 3.5%. They indicate that this was caused by the rapid and substantial increase in the population size of telephone numbers in the U.S. (435 million in 1990 versus 770 million in 1999), and that that increase was much larger than the increase in residential landline telephone service. Piekarski and Tucker (2004) calculated that equal probability of selection (Epsem) list-assisted RDD samples (i.e., 1+ working banks define the frame) encountered a working residential number rate of 55.7% in 1988, and that in 2004 the working number rate should be 40.6%, a decline of 15 percentage points.

The increase in out-of scope telephone numbers in list-assisted RDD samples has several major implications: 1) costs are increased because interviewers spend time calling numbers that are ultimately classified as out-of-scope, 2) interviewers spend less time screening and interviewing households and this may reduce morale and increase interviewer error, and 3) the survey field period will be extended. Another problem should also be mentioned. Non-contact telephone numbers are generally classified as unresolved; that is, their status as residential versus nonresidential is never established. A major component of the non-contact

telephone numbers in most RDD samples is ring-no-answer numbers, which receive the maximum number of allowed call attempts and ring without being answered at each attempt (Frankel et al. 2003). Some of the ring-no-answer numbers may actually be unassigned (nonworking) numbers for which no nonworking-number tri-tone signal is given. Calling these numbers adds to the cost and time in the field of a survey.

Purging Out-Of-Scope Telephone Numbers From RDD Samples

Battaglia, Starer, Oberkofler and Zell (1995) presented a paper at AAPOR in 1995 discussing the concept of purging out-of-scope telephone numbers from RDD samples as a way to raise the residential working number rate in the interviewer-dialed sample and to increase the cost-efficiency of RDD samples. They discussed the use of Genesys-ID, a product of Marketing Systems Group, to remove a portion of the nonworking and business telephone numbers from RDD samples and showed results, based on the National Immunization Survey (NIS), for 78 geographic areas covering the entire U.S. Back in 1995 one of the reactions to the paper was "why bother purging out-of-scope telephone numbers when with one or two call attempts the interviewers would eliminate them anyway?" We now know that purging RDD samples of out-of-scope telephone numbers (also referred to as "sample scrubbing") is an important method for reducing RDD survey costs.

In our discussion of the history of sample purging, we note that the procedure takes on added importance today in terms of eliminating cellular telephone numbers from RDD samples, and avoids the legal problems associated with dialing cellular telephone numbers using auto-dialer devices. Cellular telephone numbers may show up in RDD samples based on numbers drawn from mixed-use telephone numbers, and based on numbers ported from landline to cellular service (Kulp 2004, Piekarski 2004). By early 2004 about 250,000 telephone numbers had been ported from landline (wireline) to cellular (wireless). Kulp (2004) found that around 55% of landline to cellular ports occurred in banks containing zero residential directory-listed telephone numbers. This could indicate that many of the ported numbers to date have been business-use telephone numbers. RDD samples have also been encountering non-ported cellular telephone numbers in POTS exchanges. At the 2005 Cell Phone Summit, Kulp indicated that about one million cellular telephone numbers are embedded in POTS exchanges. Independent telephone companies use most of these

exchanges. For example, Link and Town (2005) found that Kansas had the highest percentage of cellular telephone numbers in the Behavioral Risk Factor Surveillance System (BRFSS) state RDD samples. Fortunately, Telcordia has started to provide information on 1,000-series banks, so rather than simply classifying exchanges, one can now also classify 1,000-series banks within telephone exchanges into dedicated land-line, dedicated cellular, or mixed-use.

The History Of RDD Sample Purging

Sample screening was created to increase the productivity of RDD samples. As previously noted, RDD samples contain out-of-scope telephone numbers. Out-of-scope telephone numbers include non-working (unassigned) telephone numbers, non-residential telephone numbers (i.e., business numbers), residential numbers used only for non-voice purposes and cellular numbers.

Genesys-ID

Genesys-ID or conventional screening was the first sample screening process created. It identified and removed a portion of the non-residential and non-working numbers from an RDD sample. The process utilized a business database to identify and remove listed business numbers and an automated dialing phase to identify non-working numbers by listening for a tri-tone before a connect was made. Before these two steps were carried out, residential directory-listed telephone numbers were set aside. Genesys-ID provided a report of how many numbers had been purged from the sample file broken down by business versus nonworking.

Genesys-ID typically identified about 15% of the sample as non-productive. In 1995, Battaglia, Starer, Oberkofler and Zell presented a paper at AAPOR, "Pre-Identification of Non-Working and Business Telephone Numbers in List-Assisted Random-Digit-Dialing Samples", which describes in detail the Genesys-ID process and showed results from 1995 of the sample screening process by 78 Immunization Action Plan (IAP) areas for approximately 1 million sample telephone numbers. The IAP areas are geographic strata in the National Immunization Survey. The mean unweighted percentage of the total sample for each IAP area that was identified as either nonworking or business numbers was 16.8%. The 78 IAP area unweighted average was 12.3% identified as nonworking and 4.5% identified as business. The unweighted mean percentage of all nonworking and business numbers removed from the sample was

estimated to be 34.1%. There was, however, considerable variation by IAP area. Before the calling of the sample telephone numbers that are not identified as out-of-scope, it was possible to compute an expected residential working number rate based on the percent of all nonworking and business numbers removed from the sample by Genesys-ID; the IAP area average was an expected working number rate of 61.3% (i.e., only 4 out of 10 sample telephone numbers called by interviewers were expected to be out-of-scope). We again saw considerable variation across the IAP areas. As a measure of the effectiveness of the identification process, the before versus after pre-identification percent change in the expected working number rate was computed. The 78 IAP area average percent increase in the expected working number rate was 18.6%. We also conducted research in 1995 which found that Genesys-ID purged some numbers that were actually residential numbers (based on interviewer calling) but that the false positive rate was very low (there will always be a time lag between purging the numbers and the interviewer calling and that adds to the false positive rate due to nonworking telephone numbers being put into service), and that the cost benefits swamped the false removal of a very small percentage (1.4%) of the residential telephone numbers in an RDD sample.

Genesys-IDplus

The dialing phase of Genesys-ID was an automated process. Using telephony cards and proprietary software, records not identified as a listed business or listed residential number were dialed. The software listens for the tone that identifies a number as a disconnect, fax or modem. The call was almost always terminated before the first full ring occurred. Although revolutionary at the time, changes in phone systems, phone assignment and a decline in the working phone rate of RDD sample prompted a need for a more sophisticated screening process. For example, tri-tones that identify a number as disconnected may not occur before the first ring (the same can be said for fax and modem tones). Genesys-IDplus was created and released in the fall of 1999. Genesys-IDplus builds on the predictive dialing technologies of Genesys-ID and moves the dialing process from an automated process to a manned process.

The Genesys-IDplus process performs the same database look-ups as Genesys-ID. The sample file is first matched to the listed residential file and records identified as listed residential numbers are flagged and set aside. The remaining numbers in the RDD sample file are then matched against a business purge

database of approximately 13 million records; records matched as a listed business number are removed from the sample file. All remaining records not identified as a listed residential or business numbers are sent to the dialing phase. The dialing phase of Genesys-IDplus starts with a match to a third database of recently dialed numbers and their dispositions. The database includes records that have been dialed in the past 3 months that were identified as residential (unlisted residential), business (unlisted business) and non-working. If any of the telephone numbers in the sample file are in the file of recently dialed numbers, the numbers are dispositioned accordingly and not dialed.

The dialing phase is a manned process. The sample file is loaded into the Genesys-IDplus software and then dialed using PRO-T-S, a research predictive dialer. All connects are routed to an interviewer for disposition. An attempt is made by the interviewer to determine whether the connect is a business or residence. In addition, non-working numbers that do not have a tri-tone are also identified and dispostioned as such. Genesys-IDplus allows the phone to ring up to 2 times before terminating the call. The calls are made 9:00AM to 5:00PM local dialing time to reduce the intrusion into the households. Genesys-IDplus assigned a set of flags in the sample file to identify the telephone numbers that had been identified as nonworking and business numbers. Before starting data collection these numbers would need to be removed from the sample file.

Genesys-IDplus typically purges an average of about 35% of the sample file as out-of-scope numbers, which is about 75 to 80% of the non-productive numbers. For each IAP area in the National Immunization Survey, the percentage of telephone numbers that Genesys-IDplus eliminated from the initial sample (all replicates) for 2003 was calculated. Also calculated was the percentage breakdown of the eliminated numbers by nonworking, business, and fax/modem. The overall percentage of telephone numbers eliminated was 41.0%. IAP areas with the highest percentage of numbers eliminated included Michigan–City of Detroit (52.2%), Nebraska (50.7%), and South Dakota (50.2%). IAP areas with the lowest percentage of numbers eliminated included West Virginia (30.9%), Texas–Bexar County (32.2%), and Delaware (32.8%). The middle half of the IAP areas ranged from 36.4% to 44.5%.

Figure 1 shows that IAP areas with a higher percentage of numbers eliminated had a higher percentage of the eliminated numbers identified as

nonworking. This pattern is not surprising because a high percentage of the nonresidential numbers in the U.S. are nonworking numbers. Thus, the elimination of business numbers has less impact on the total amount of sample eliminated by Genesys-ID*plus*. The overall percentage of eliminated numbers classified as businesses was 24.2%. California–San Diego County, California–Los Angeles County, and Massachusetts–Rest of State had the highest percentages of business eliminated numbers (33.9%, 33.6%, and 33.0%, respectively), but their percentages of sample numbers eliminated were only 35.7%, 36.6%, and 33.9%, respectively. In summary, nonworking numbers are the main contributor to the elimination by Genesys-ID*plus* of a high percentage of the telephone numbers in the sample.

The results for 2003 represented an increase over 2002: 41.0% of telephone numbers were eliminated, up from 39.8%. The bulk of the increase came from nonworking numbers, up 1.4 percentage points; business numbers and fax/modem numbers each decreased by 0.1 percentage point. Among the 78 IAP areas only 12 did not have a higher percentage of telephone numbers eliminated in 2003 than in 2002. Preliminary results for 2004 indicate that 43.9% of sample telephone numbers were purged. As with Genesys-ID we also conducted research using the NIS sample, which found that the percentage of residential numbers in the RDD sample falsely eliminated by Genesys-ID*plus* continued to be very low.

The standard interviewer calling procedure in the NIS required three fax/modem call dispositions for a number to be classified as out-of-scope, because a fax/modem line could also be used for voice purposes (e.g., a fax/machine that is used on a telephone line that is used primarily for voice calling). With the switch from Genesys-ID to Genesys-ID*plus,* telephone numbers that Genesys-ID*plus* identified as fax/modem were eliminated. Thus some of the fax/modem sample numbers were being eliminated essentially after one call attempt. Using a sample of 10,214 telephone numbers that Genesys-ID*plus* identified as fax/modem, these numbers were processed through Genesys-ID*plus* two additional times during weekday evening hours (local time). After the second dialing 7,824 of the 10,124 numbers were still identified as fax/modem. Those 7,842 numbers were dialed a third time and 7,204 yielded a fax/modem outcome (i.e., these numbers had three fax/modem results). We took the numbers that did not yield a fax/modem result to all three attempts and released them to the interviewers for calling. The interviewers ended up dispositioning 149 numbers as

residential. This represents 1.5% of the 10,124 numbers that Genesys-ID*plus* identified as a fax/modem outcome based on one attempt. It was therefore decided that it was reasonable to use Genesys-ID*plus* to purge fax/modem numbers from the NIS sample, and thus the use of Genesys-ID*plus* on the NIS reflects the purging on nonworking, business and fax/modem numbers from the sample.

Genesys-CSS

One of the other out-of-scope categories that has not yet been addressed is cellular phone numbers. Although RDD samples have always had the possibility of including cellular phone numbers because of the inclusion of mixed use exchanges, their presence and the need to identify them has become a more pressing issue. The Telecommunications Act of 1996 introduced Number Portability. Landline-to-Landline portability was introduced in 1998 to allow for fair competition among telephone companies. One could switch phone carriers while maintaining the same phone number. From a sampling standpoint wireline to wireline number portability has had little to no effect. In November 2003, wireline to wireless number portability was introduced in the top 100 metro markets and in the rest of the US in May 2004. This allowed consumers the flexibility to transfer their landline phone number to a cellular phone. In the past, wireless numbers were restricted to specific exchanges and thousand blocks that could be easily identified. With wireline to wireless number portability cellular numbers could appear in any exchange or thousand block including those classified for residential use. Although survey researchers are not restricted from calling cell phone numbers, there are restrictions on using automated dialing devices to call cell phone numbers.

There are currently two ways to identify ported cellular phone numbers in a sample. One way is using the NeuStar database. NeuStar Inc. is the North American Numbering Plan (NANP) administrator. Since the inception of wireline to wireless number portability NeuStar has compiled a database of wireline to wireless ported numbers. Initially this database was not available for commercial use until the spring of 2004. The Neustar database is licensed on an annual basis and can be downloaded daily for the most up-to-date list. Each company that uses a file matched to the NeuStar database must be licensed to use the data. By tracking the number of records in the NeuStar database we can see the growth of number portability.

- June 14, 2004 – 398,409 records
- July 29, 2004 – 626, 131 records
- November 16, 2004 – 1,014,569 records
- April 8, 2005 – 1,521,118 records

Another option for identifying cellular numbers in a sample is Genesys-CSS. Genesys-CSS takes Genesys-ID*plus* one step further and identifies all types of cellular numbers, not just ported cellular numbers. Genesys-CSS matches the sample file to the listed business database, matched records are set aside and all remaining records are sent to the dialing phase. Only listed, published business records are excluded from the dialing phase. Unlike Genesys-ID*plus*, listed residential numbers are not set aside. Instead, they are dialed. This enables two criteria to be met. All records not previously identified as a listed business number are processed for cell phone identification. Also, by dialing the listed residential numbers, a greater increase in productivity can be seen. The listed database typically has an 85 to 90% list accuracy, which means that about 10 to 15% of the numbers in a listed household frame will be out of scope numbers. By screening these numbers for disconnects, businesses, etc., more out of scope numbers are identified, thus increasing the productivity of the sample. Genesys-CSS identifies cellular numbers by using a proprietary process that screens each number in the sample file (less the published businesses). Any record that is identified as a cellular number is flagged and set aside. The remaining numbers are dialed and dispositioned accordingly.

A Comparison Of Genesys-IDplus And Genesys-CSS

As part of the effort to improve the National Immunization Survey, new procedures are tested before implementing them on a large-scale basis. In the fourth quarter of 2004, one sample replicate from the NIS was processed through Genesys-CSS. The objective was to compare the sample purging results of Genesys-CSS with Genesys-ID*plus*, which the NIS had been using for several years. One benefit of Genesys-CSS is the identification of cellular telephone numbers in an RDD sample. On the other hand, because Genesys-CSS does not set the residential directory-listed numbers aside, we wanted to examine those numbers identified as business, nonworking or fax/modem. Table 1 summarizes the classification of telephone numbers in the Q4/2004 sample replicate. Genesys-CSS was used to identify phone numbers that were flagged for elimination (business, nonworking, modem, and cellular).

Because we know the residential-directory listed status of the telephone numbers and whether they are from POTS versus mixed-use telephone exchanges, we can identify the telephone numbers flagged by Genesys-CSS that would have *not* been flagged for elimination by Genesys-ID*plus*. The italicized figures are the numbers that would have been eliminated by Genesys-ID*plus,* and the figures in blue are the telephone numbers released to the telephone center. The figures in blue in the Business, Modem, and Nonworking rows of Table 1 represent the telephone numbers that CSS would flag for elimination but Genesys-ID*plus* would not flag for elimination.

Note that in Table 2, 21.2% of the residential directory-listed telephone numbers in POTS exchanges were flagged as business, modem, or nonworking numbers. The residential directory-listed telephone numbers flagged as business telephone numbers resulted from the business data file matching or through an agent-answered call that classified the number as business. Among numbers that are not residential directory-listed numbers in the POTS exchanges, 67.0% were identified as business, modem, or nonworking numbers. For the mixed-use exchanges the corresponding percentages are 20.2% and 50.1%, respectively. Across the entire sample replicate of 43,918 telephone numbers, a total of 56 (0.13%) cellular numbers were identified. Table 2 shows that Genesys-CSS eliminated considerably more telephone numbers than Genesys-ID*plus* (51.3% versus 43.9%).

A validation test of Genesys-CSS was put in place in the fourth quarter of 2004 by identifying residential directory-listed telephone numbers that Genesys-CSS classified as business, nonworking, or modem. We limited this sample of telephone numbers to those where the time lag between running Genesys-CSS ands the first interviewer call attempt was less than or equal to 30 days. These numbers (386 identified as business numbers, 148 identified as fax/modem numbers, and 1,712 identified as nonworking numbers) were released to the interviewers for dialing following standard NIS calling procedures. Table 3 summarizes the result of calling the residential directory-listed telephone numbers identified by Genesys-CSS to be out of scope that would have not been eliminated by Genesys-ID*plus* (not all of the interviewer outcome categories are shown in Table 3, e.g., ring-no-answer outcomes). Keep in mind that there was a time lag between running Genesys-CSS and the first and last interviewer call attempts on these numbers. Of the numbers purged as business numbers, the

interviewers classified 28.5% as known residential telephone numbers. In the NIS, numbers that are reported to be used for both residential and business purposes are treated as residential numbers. This along with the time lag may account for much of the discrepancy found here. For the other two groups of numbers a much lower percentage of the numbers were classified as known residential numbers. Some disagreement was expected for the nonworking numbers due to the time lag causing nonworking numbers being put into service. The business category accounts for only 1.3% of the total RDD sample ((550 + 12) / 43,918) and so the impact of false positives should not be a great concern. It is worth noting that Genesys-CSS flags numbers for removal and there is the option of not removing the residential directory-listed numbers that are flagged as business numbers.

Conclusions

Sample screening is an effective way to remove out-of-scope telephone numbers from RDD samples. The improvements made over the past 10 to 15 years have increased the percentage of out-of-scope numbers that can be purged before releasing the sample for interviewer calling. This in turn has helped to reduce data collection costs or more accurately, has lowered the increase in data collection costs that have been experienced due to other factors. The latest methods make it possible to purge cellular telephone numbers from RDD samples. One limitation of the current methods is that they cannot identify unassigned telephone numbers that yield a ring-no-answer when called rather than the tri-tone nonworking signal. Work is currently being carried out in this area.

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Figure 1: Relation between Percentage of Initial Sample Eliminated for an IAP Area and Percentage of Eliminated Numbers That Were Nonworking, Q1-Q4/2003
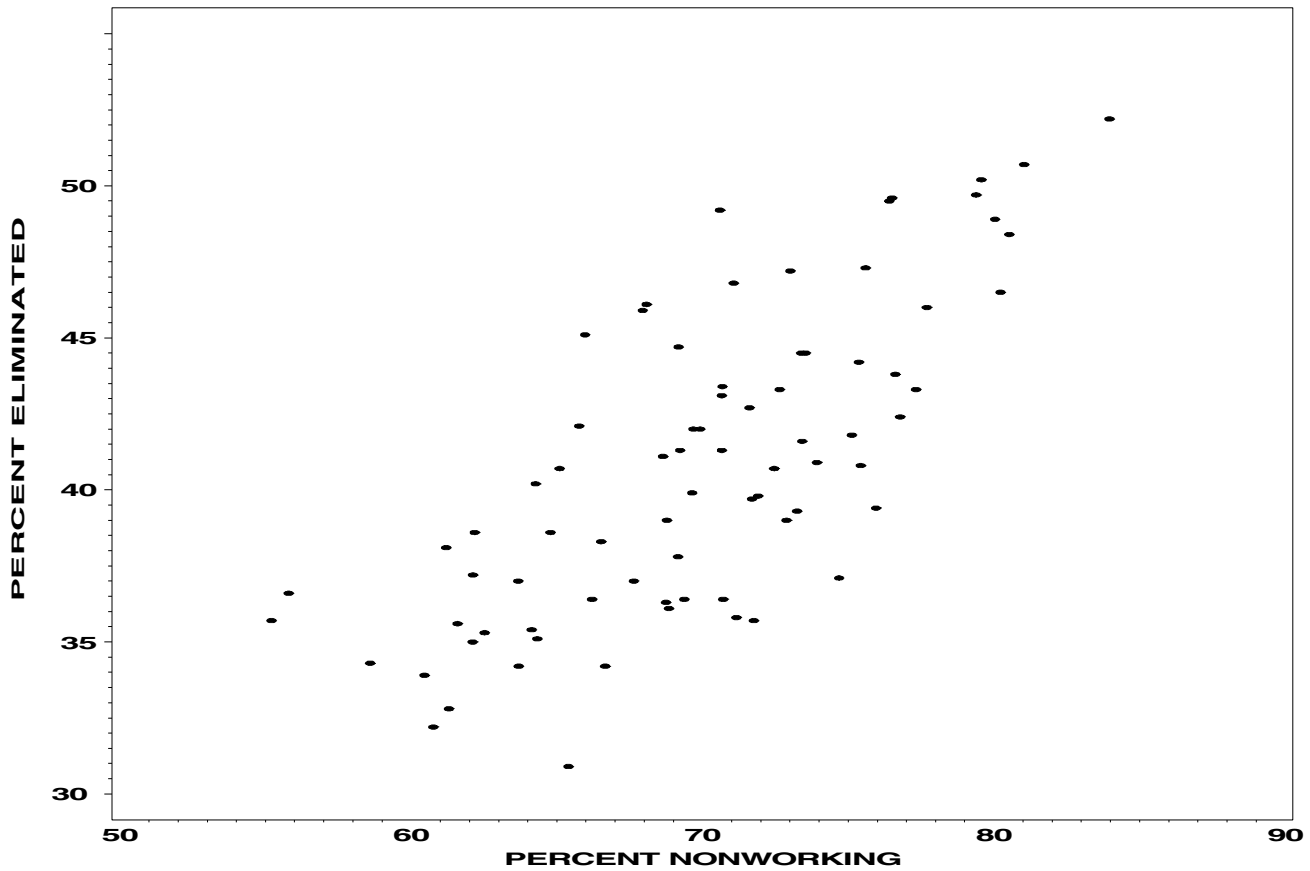

Table 1: Frequency and Percentage Distributions of Telephone Numbers Classified by Genesys-CSS Status Code and Residential Directory-Listed Status

CSS Status Code	Sample Draw Identified POTS Exchanges				Sample Draw Identified Mixed Use Exchanges				TOTAL
	Residential Directory- Listed Status of Number				Residential Directory- Listed Status of Number				
	Listed		Not Listed		Listed		Not Listed		
	Count	Percent	Count	Percent	Count	Percent	Count	Percent	
Business	550	3.74	4,035	14.35	12	2.86	96	10.93	4,693
Agent Identified Cell Phone	1	0.01	14	0.05	0	0.00	0	0.00	15
Good Outcome (Residence, Residential Answering Machine, Ring-No Answer, Busy	10,911	74.17	8,842	31.44	279	66.43	231	26.31	20,263
Modem	203	1.38	840	2.99	7	1.67	22	2.51	1,072
Nonworking	2,368	16.10	13,971	49.68	66	15.71	322	36.67	16,727
Privacy Manager Encountered	663	4.51	395	1.40	19	4.52	7	0.80	1,084
Wireless Detection	14	0.10	21	0.07	2	0.48	4	0.46	41
Mixed Use Exchange	0	0.00	4	0.01	1	0.24	18	2.05	23
TOTAL	14,710	100.00	28,122	100.00	420	100.0	878	100.00	43,918

Note: **Blue Text: Released to Telephone Center**
Green Background: Not Submitted to Computer Integrated Dialing; Possible Cell Phone
Bold Italics: Genesys-IDplus Eliminated

Table 2: Frequency Distribution of Telephone Numbers Eliminated by Genesys-ID*plus* and Genesys-CSS by the Genesys-CSS Classification Code

CSS Status Code	Genesys-ID*plus* Eliminated	Genesys-CSS Eliminated
Business	4,131	4,693
Agent Identified Cell Phone	-	15
Modem	862	1,072
Nonworking	14,293	16,727
Wireless Detection	-	41
TOTAL	19,286	22,548
Percent of total replicate	43.9%	51.3%

Table 3: Genesys-CSS validation results

Residential directory listed numbers identified by Genesys-CSS as **business** numbers (n=386)	Residential directory listed numbers identified by Genesys-CSS as **fax/modem** numbers (n=148)	Residential directory listed numbers identified by Genesys-CSS as **nonworking** numbers (n=1,712)
59.3% were dispositioned by interviewers as **business** numbers	64.2% were dispositioned by interviewers as **fax/modem** numbers	88.1% were dispositioned by interviewers as **nonworking** numbers
4.9% were dispositioned by interviewers as **possible residential** numbers	1.4% were dispositioned by interviewers as **possible residential** numbers	1.9% were dispositioned by interviewers as **possible residential** numbers
28.5% were dispositioned by interviewers as **known residential** numbers	13.5% were dispositioned by interviewers as **known residential** numbers	6.8% were dispositioned by interviewers as **known residential** numbers