Scope and Coverage of Landline and Cell Phone Numbers Appended to Address Frames

Rachel Harter[1] and Joseph McMichael[1]
[1]RTI International, P.O. Box 12194, Research Triangle Park, NC 27709

Abstract
With the commercial availability of address-based sampling frames sourced from the U.S. Postal Service files, address-based sampling is offered as a higher coverage alternative to random digit dialing samples. Telephone contacts and data collection are less expensive than their in-person counterparts, however, so some vendors append telephone numbers to addresses where their sources indicate a match. The coverage of the addresses with telephone numbers is far from complete, leading to an increase in mixed mode surveys, where the alternative is often in-person. The greater the coverage of the telephone numbers, the lower the cost of the survey.

In this paper we explore the availability of landline and cell phone numbers appended to a sample of 12 million addresses from the Computerized Delivery Sequence file licensed from Valassis. We summarize the phone coverage by geography, geographical demographics, and address characteristics, putting aside the issues of address coverage of the household population and the accuracy and viability of the telephone numbers themselves. Knowledge of phone coverage for subpopulations increases the information available to sample designers.

Key Words: address based sampling, ABS, mixed mode, coverage, phone, CDS

1. Introduction

As Blumberg and Luke (2012) have documented in recent years, U.S. households are increasingly equipped with cell telephones, with or without traditional landline phones. Conversely the proportion of households with a landline phone is decreasing. Therefore, traditional Random Digit Dial (RDD) telephone surveys, which were based on samples of landline telephone numbers, are increasingly at risk of bias for omitting households that do not have a landline phone. For example, Blumberg and Luke (2009) found potential for bias in the National Health Interview Survey when estimating health and behavior traits for young adults when only landline phones were included.

One alternative approach is to supplement a landline sample with a sample of cell telephone numbers so that all households with any phone have a chance of selection. The resulting survey can still be telephone mode exclusively, although current law prohibits automatic dialing of cell numbers, increasing the costs.

Another alternative is to begin with a sample drawn from a frame of addresses so that the type of telephone coverage, if any, is not a coverage issue. Address based sampling (ABS), discussed extensively by Iannacchione (2011), has been used for many years for mail surveys and face-to-face surveys. Data collection face-to-face is very expensive, and both of these modes require more time than telephone interviewing for comparable contact attempts. Some organizations are going to mixed mode surveys, where the sample of addresses is selected, and telephone numbers are appended to as many addresses as possible. The addresses with a phone number appended can be approached by phone, while the remainder can be approached by some other mode. Therefore, the greater the proportion of addresses with working telephone numbers appended, the more potential for data collection efficiency, especially if the alternative is face-to-face.

When planning an ABS mixed mode survey, the sampling statistician needs to know various rates to determine the size of the initial sample to select. In addition to the usual response rates among eligible households, and the eligibility rates among all households, the designer should know how well the frame covers the target population. In this ABS/mixed mode context, the designer also needs to know the proportion of addresses expected to have telephone numbers appended, and the proportion of appended phone numbers that are accurate.

The usual address frames for ABS sampling are derived from the U.S. Postal Service's Computerized Delivery Sequence (CDS) file and obtained from a marketing vendor. Generally only two vendors can make versions of the CDS available for essentially the total U.S. population of residential addresses. How well the CDS file covers the population of U.S. housing units (or just occupied housing units) has been the subject of much research. When the use of the CDS for surveys was new, Iannacchione et al. (2003) and O'Muircheartaigh et al. (2003) discussed frame coverage in the context of specific studies. The concensus of many such papers is that the CDS file covers the target population of housing units very well in urban and suburban areas, but coverage is more problematic in rural areas where P.O. boxes, Rural Route boxes, and other non-city-style addresses are more prevalent. Coverage can vary from one geographical region to another, so subnational surveys need coverage information for their targeted geographies. McMichael et al. (2012) presented coverage information for individual states.

The CDS file can be supplemented with a recently available companion file, the No-Stat (NS) file. The NS file contains addresses for vacant units and throwbacks on rural route and highway contract carrier routes, addresses for some units at drop points, and new construction. See Iannacchionne (2011) for more information on the NS file and clarification of these types of addresses. While some of the addresses in the NS file are assumed to be active, particularly the rural throwback addresses, most addresses in the NS file are assumed to be vacant or otherwise inactive for mail delivery. Shook-Sa et al. (2012) describe the NS file in greater detail, focusing on its potential to increase the address frame's coverage of the population of housing units.

After the address frame's coverage of the target population, the second issue is the proportion of frame addresses for which phone numbers can be obtained, also referred to as the append rate. The phone append rate was first addressed by Murphy et al (2010) for a specific set of relatively local surveys. The phone append rate, nationally and for subnational areas, is the focus of this research.

The third issue is the accuracy and reliability of the telephone numbers appended to sample addresses. A higher append rate is desirable if the phone numbers are working numbers that really do reach the household at the sample address. If the quality of phone appends is poor, however, an increased append rate may not result in any efficiencies. The quality of phone appends is addressed in papers by McMichael and Harter (2012) and Murphy et al. (2010).

Section 2 describes the methodology used to estimate the current phone append rates for three vendors, including one that supplies cell numbers as well as landline numbers. The estimates are shown in Section 3 for the total U.S., for individual states, and for other subnational geographies. Section 3 also summarizes the append rates for different types of addresses and for different levels of urbanicity, which could be very important in designing a subnational survey.

2. Methodology

2.1 Another Secondary Subhead

The starting point for this research was the February 2012 CDS file as obtained from Valassis, along with the corresponding No-Stat file. We selected a very large systematic sample of approximately 12,000,000 addresses from the combined CDS and NS files. The sample was so large to provide estimates of phone match rates for subnational geographies and for subsets of the frame corresponding to address types.

RTI's version of Valassis' CDS file contained a flag indicating addresses for which a telephone number was available. For this analysis we did not need the actual phone numbers, just the indicators of whether a phone number was available. The Valassis telephone flag was based on a match of landline phone numbers.

For comparison, we submitted the sample to two other vendors to obtain their corresponding flags for the availability of a telephone number. Consumer Base provided separate flags for available landline and cell phone numbers. Consumer Base is one of the first vendors to offer cell phone number appends, which is an exciting development. The other vendor that supplied phone number flags was Marketing Systems Group (MSG). MSG's flags are restricted to nominally landline phone numbers, but they draw on multiple sources, increasing the number of phone matches overall.

Once we had all of the phone flags appended to the sample file, we summarized the estimated proportions $\hat{p}$ with flags by various geographic and address type subgroups. Let N and n be the population and sample sizes for a domain of addresses in the frame, and let δ_i be an indicator variable for the presence of a phone number for address i in the domain sample. Then the estimated proportion is the simple sample mean of the indicator value

$$\hat{p} = n^{-1} \sum_{i=1}^{n} \delta_i \, .$$

The estimated standard error of an estimated proportion $\hat{p}$ based on a sample of size n is given by

$$\sqrt{\frac{(N-n)}{N} \frac{\hat{p}(1-\hat{p})}{n}},$$

where the finite correction factor $(N-n)/N$ is the same for all subdomains because the sampling rate is the same throughout. The estimated proportions and their standard errors are summarized in Section 3.

3. Estimates

2.1 Total U.S.

First we summarize the estimated phone append rates for the total U.S. Figure 1 shows the append rates for the CES file separately from the NS file. Valassis' append rate for the NS file is zero because no match was attempted. Notice that both Consumer Base and MSG have phone numbers for some addresses in the NS file, indicating that some coverage may be gained by including this file. Nevertheless, the CDS file has substantially higher append rates across all vendors.

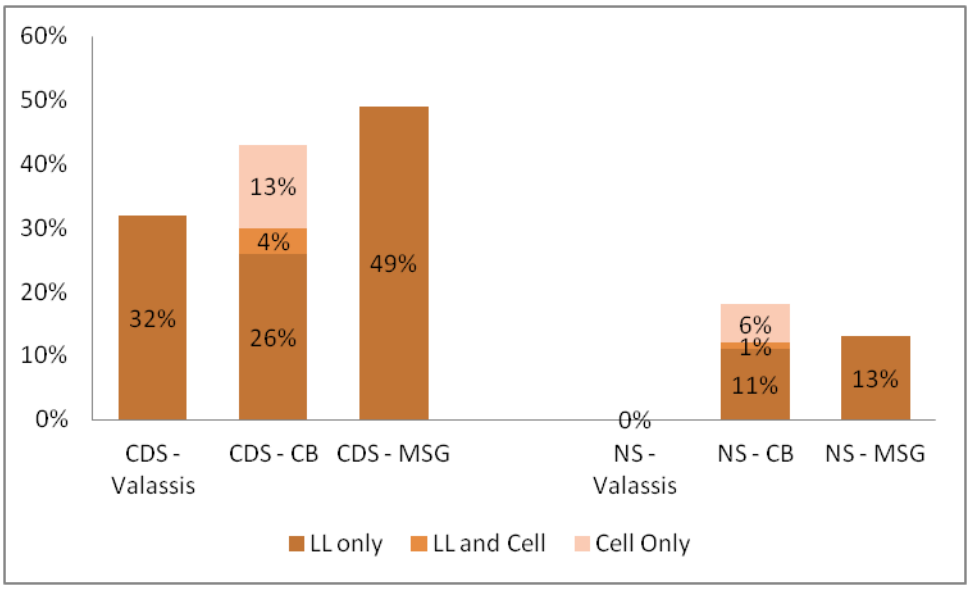

Figure 1: Percentage of Total U.S. Addresses with Phone Number Matches Available, By Address File and Vendor

The match rate varies by the nature of the address. City-style addresses have far more phone appends than any other type of address. The next major category of interest is that of Post Office boxes that are designated Only Way to Get Mail. That is, the OWGM addresses are active addresses for households that receive mail no other way. The addresses are practically worthless for geocoding or in-person surveys, but having phone numbers available means there is an alternative to mail for these households. Figure 2 shows the phone match rates for different types of addresses. The city-style addresses, OWGM, and other addresses account for 99%, 1%, and nearly 0% of the sample, respectively.

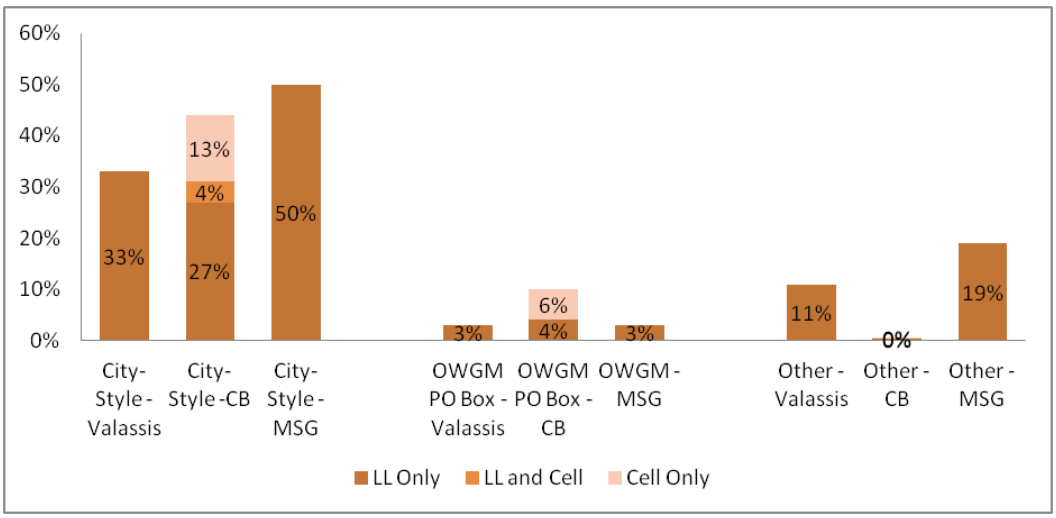

Figure 2: Percentage of Total U.S. CDS File Addresses with Phone Number Matches Available, By Address Type and Vendor

It is widely understood from prior research (Iannacchione 2011, O'Muircheartaigh et al. 2003) that the address frames have very high rates of locatable addresses in urban areas, but rural areas have a higher prevalence of P.O. boxes, rural route boxes, and other non-city-style addresses. Many survey designs require specific knowledge of an addresses location, either for in-person visits or for establishing eligibility for a targeted geographical area. So while the entire address frame may cover households well, the locatable addresses cover urban areas better than rural areas. For this reason, it is useful to know whether the phone match rates ameliorate or add to the coverage disparity. Rather than assign urban or rural status to every address in the sample, as a first step we used the Valassis indicator as to whether or not the address was part of a county contained in a Core Based Statistical Area (CBSA), as defined by the Office of Management and Budget (2000).

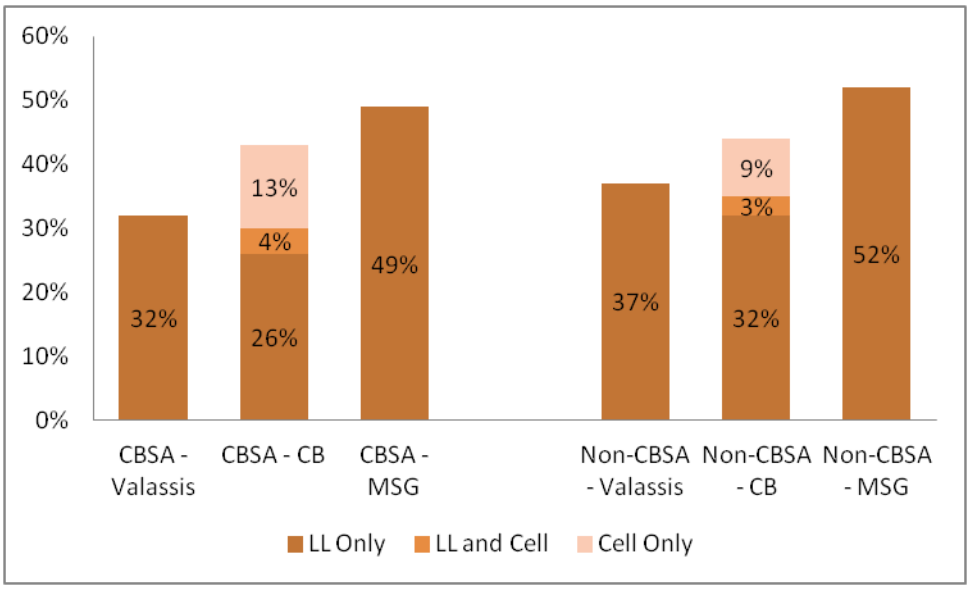

Figure 3: Percentage of Total U.S. CDS File Addresses with Phone Number Matches Available by CBSA Status and Vendor

Figure 3 shows that non-CBSA counties actually have higher phone match rates than urban areas. It is plausible that households in rural areas change telephone service less often and are listed more often, resulting in higher phone match rates. Figure 3 indicates that non-CBSA counties have a larger percentage of landline phone matches. CBSA and non-CBSA addresses account for 94% and 6% of the total sample, respectively.

Figure 4 shows the phone match rates for two special types of addresses, those flagged by Valassis as vacant and those flagged as seasonal. While addresses do not change much, an address' vacancy status can change frequently. Survey designers have the option of including or excluding vacant and seasonal housing units, depending on eligibility and coverage requirements. The phone match rates are low for these households, as expected, but not insignificant. The time lag between the production of the address file and the match to phone databases may be contributing to the number of addresses with an apparent match. These housing units comprise a small portion of the overall sample, with 3% of the sample flagged as vacant and .7% flagged as seasonal.

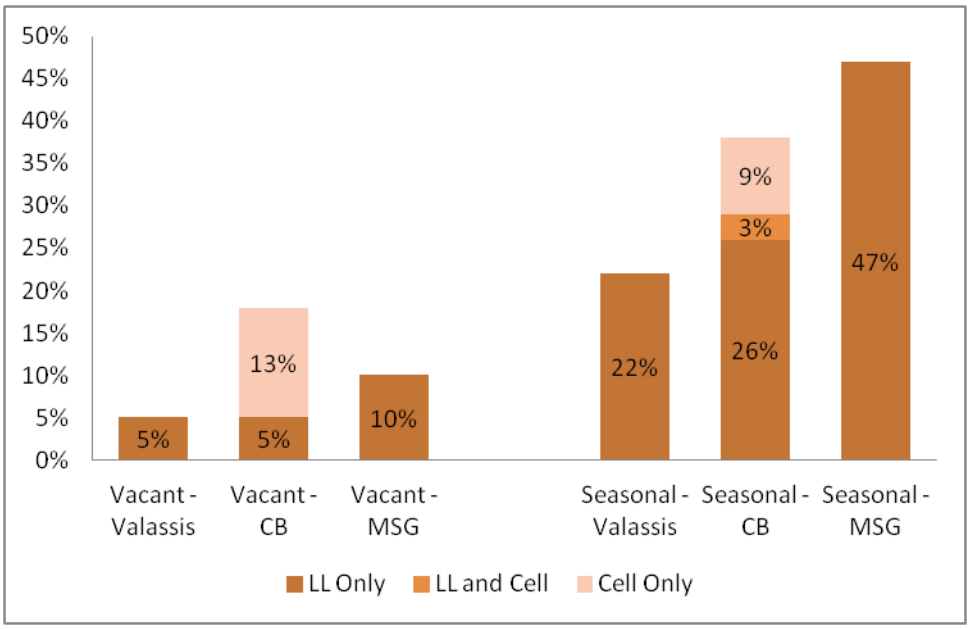

Figure 4: Percentage of Total U.S. CDS File Vacant and Seasonal Addresses with Phone Number Matches Available, By Vendor

3.2 States and Other Sub-National Areas

Similar summaries of telephone match rates by address file, by address type (city-style and OWGM), and by CBSA or Non-CBSA counties were produced for the 50 states plus the District of Columbia. The results are shown in Tables 1-3. Summaries for vacant and seasonal addresses are not shown.

Blumberg and Luke (2012) typically provide landline and cell phone rates for sub-national geographies that are often sub-state, as well. These sub-national areas are used for a variety of surveys sponsored by the Centers for Disease Control and Prevention, so the rates may be useful to planning future cycles of these ongoing surveys. These sub-national rates are also available in Tables 1-3, along with the state estimates.

Table 1: Phone Number Match Rates to Addresses by Address File and Vendor
V = Valassis, CB = Consumer Base, MSG = Marketing Systems Group

	CDS Match Rates (%)						*NS Match Rates (%)*			
	V		*CB*		*MSG*		*CB*		*MSG*	
State/Area	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*
Alaska	11	0.2	22	0.3	18	0.2	7.5	1	4.4	0.8
Alabama	40	0.1	46	0.1	55	0.1	16	0.2	11	0.2
Jefferson County	41	0.3	49	0.3	56	0.3				
Rest of Alabama	40	0.1	45	0.1	55	0.1				
Arkansas	31	0.1	39	0.1	44	0.1	18	0.3	9	0.2
Arizona	23	0.1	35	0.1	38	0.1	11	0.2	8.2	0.2
Maricopa County	24	0.1	37	0.1	40	0.1				
Rest of Arizona	22	0.1	33	0.1	36	0.1				
California	25	0	38	0	42	0	13	0.2	11	0.2
Alameda County	26	0.2	39	0.2	45	0.2				
Fresno County	25	0.2	37	0.3	41	0.3				
Los Angeles County	24	0.1	35	0.1	40	0.1				
Northern Counties	29	0.2	39	0.3	45	0.3				
Rest of California	26	0.1	40	0.1	44	0.1				
San Bernardino County	24	0.2	36	0.2	40	0.2				
San Diego County	22	0.1	36	0.1	36	0.1				
Santa Clara County	26	0.2	42	0.2	46	0.2				
Colorado	31	0.1	42	0.1	48	0.1	13	0.3	12	0.3
City of Denver Counties	30	0.2	39	0.2	46	0.2				
Rest of Colorado	31	0.1	44	0.1	48	0.1				
Connecticut	35	0.1	54	0.1	62	0.1	37	0.9	39	0.9
District of Columbia	22	0.2	36	0.3	42	0.3	14	1.8	13	1.8
Delaware	42	0.3	52	0.3	62	0.3	13	0.5	12	0.4
Florida	31	0	43	0.1	47	0.1	15	0.1	11	0.1
Dade County	29	0.1	35	0.2	43	0.2				
Duval County	31	0.2	41	0.2	48	0.3				
Orange County	25	0.2	42	0.2	36	0.2				
Rest of Florida	31	0.1	44	0.1	48	0.1				
Georgia	37	0.1	38	0.1	50	0.1	14	0.2	9.2	0.1
Fulton/DeKalb Counties	31	0.2	36	0.2	45	0.2				
Rest of Georgia	38	0.1	39	0.1	51	0.1				
Hawaii	21	0.2	32	0.2	30	0.2	14	0.8	10	0.7
Iowa	39	0.1	50	0.1	57	0.1	35	0.4	36	0.4
Idaho	29	0.2	38	0.2	42	0.2	13	0.5	10	0.5
Illinois	32	0.1	44	0.1	50	0.1	22	0.2	17	0.2
Cook County	27	0.1	40	0.1	44	0.1				
Madison/St Clair Counties	39	0.3	50	0.3	57	0.3				
Rest of Illinois	36	0.1	47	0.1	54	0.1				
Indiana	36	0.1	46	0.1	55	0.1	20	0.3	14	0.3
Lake County	42	0.3	50	0.3	56	0.3				
Marion County	32	0.2	44	0.2	46	0.2				
Rest of Indiana	36	0.1	46	0.1	56	0.1				
Kansas	34	0.1	45	0.1	52	0.1	25	0.4	22	0.4
Johnson/Wyandotte Counties	35	0.3	48	0.3	56	0.3				

Rest of Kansas	34	0.2	44	0.2	51	0.2				
Kentucky	38	0.1	47	0.1	51	0.1	20	0.3	12	0.3
Louisiana	38	0.1	45	0.1	53	0.1	16	0.4	12	0.4
Massachusetts	41	0.1	52	0.1	60	0.1	35	0.6	36	0.6
Rest of Massachusetts	43	0.1	53	0.1	63	0.1				
Suffolk County	23	0.2	38	0.3	42	0.3				
Maryland	40	0.1	44	0.1	57	0.1	15	0.4	19	0.4
Baltimore City	28	0.3	36	0.3	44	0.3				
Rest of Maryland	42	0.1	45	0.1	59	0.1				
Maine	37	0.2	43	0.2	53	0.2	23	0.6	22	0.6
Michigan	38	0.1	48	0.1	54	0.1	23	0.2	17	0.2
Rest of Michigan	39	0.1	49	0.1	55	0.1				
Wayne County	36	0.2	46	0.2	52	0.2				
Minnesota	39	0.1	49	0.1	59	0.1	25	0.4	23	0.3
Rest of Minnesota	42	0.2	54	0.2	61	0.2				
Twin Cities Counties	36	0.1	46	0.1	56	0.1				
Missouri	36	0.1	45	0.1	50	0.1	22	0.3	9.9	0.2
Rest of Missouri	36	0.1	44	0.1	50	0.1				
St Louis County/City	37	0.2	48	0.2	51	0.2				
Mississippi	33	0.1	40	0.1	44	0.1	17	0.3	9.4	0.2
Montana	29	0.2	40	0.3	45	0.3	13	0.4	12	0.4
North Carolina	36	0.1	46	0.1	51	0.1	18	0.2	12	0.2
North Dakota	36	0.3	47	0.3	48	0.3	26	0.8	20	0.7
Nebraska	34	0.2	43	0.2	51	0.2	23	0.4	24	0.5
New Hampshire	40	0.2	50	0.2	62	0.2	27	0.7	22	0.7
New Jersey	36	0.1	49	0.1	55	0.1	33	0.4	26	0.4
Essex County	26	0.2	45	0.3	46	0.3				
Rest of New Jersey	37	0.1	50	0.1	56	0.1				
New Mexico	27	0.2	33	0.2	39	0.2	11	0.4	8.4	0.3
Rest of New Mexico	27	0.2	35	0.2	41	0.2				
Southern Counties	25	0.3	27	0.3	35	0.3				
Nevada	21	0.1	34	0.1	31	0.1	7.6	0.3	6.1	0.3
Clark County	20	0.1	33	0.2	27	0.2				
Rest of Nevada	26	0.3	38	0.3	40	0.3				
New York	29	0.1	40	0.1	50	0.1	22	0.3	19	0.3
City of New York Counties	21	0.1	33	0.1	45	0.1				
Rest of New York	35	0.1	46	0.1	53	0.1				
Ohio	36	0.1	46	0.1	50	0.1	19	0.3	13	0.2
Cuyahoga County	34	0.2	43	0.2	48	0.2				
Franklin County	32	0.2	43	0.2	43	0.2				
Rest of Ohio	37	0.1	47	0.1	51	0.1				
Oklahoma	34	0.1	39	0.1	44	0.1	17	0.3	6.3	0.2
Oregon	25	0.1	37	0.1	42	0.1	15	0.3	16	0.3
Pennsylvania	20	0.1	47	0.1	57	0.1	23	0.2	11	0.2
Allegheny County	16	0.2	50	0.2	58	0.2				
Philadelphia County	25	0.2	37	0.2	45	0.2				
Rest of Pennsylvania	20	0.1	48	0.1	59	0.1				
Rhode Island	37	0.2	49	0.2	55	0.2	32	1.5	28	1.4
South Carolina	35	0.1	45	0.1	48	0.1	16	0.2	10	0.2
South Dakota	39	0.3	49	0.3	55	0.3	28	0.8	22	0.7

Tennessee	37	0.1	48	0.1	52	0.1	20	0.3	13	0.2
Davidson County	29	0.3	44	0.3	46	0.3				
Rest of Tennessee	38	0.1	48	0.1	53	0.1				
Shelby County	34	0.2	46	0.3	50	0.3				
Texas	31	0	38	0	43	0.1	16	0.1	6.9	0.1
Bexar County	30	0.2	42	0.2	42	0.2				
Dallas County	29	0.1	37	0.2	42	0.2				
El Paso County	31	0.3	37	0.3	42	0.3				
Harris County	30	0.1	39	0.1	42	0.1				
Rest of Texas	32	0.1	38	0.1	44	0.1				
Utah	32	0.2	41	0.2	46	0.2	12	0.4	10	0.4
Virginia	39	0.1	47	0.1	53	0.1	19	0.3	13	0.3
Vermont	35	0.3	44	0.3	57	0.3	21	0.8	23	0.8
Washington	30	0.1	38	0.1	46	0.1	16	0.3	15	0.3
Eastern Counties	29	0.3	36	0.3	42	0.3				
King County	28	0.2	38	0.2	44	0.2				
Rest of Washington	31	0.1	37	0.2	46	0.2				
Western Counties	33	0.2	39	0.2	50	0.2				
Wisconsin	40	0.1	48	0.1	59	0.1	24	0.3	21	0.3
Milwaukee County	33	0.2	45	0.2	50	0.2				
Rest of Wisconsin	41	0.1	49	0.1	61	0.1				
West Virginia	30	0.2	32	0.2	42	0.2	19	0.3	6.4	0.2
Wyoming	28	0.3	43	0.3	38	0.3	17	1	11	0.8

*Summary statistics for the No-Stat file are available down to state level only. Valassis does not match phone numbers to the No-Stat file.

Table 2: Phone Number Match Rates to Addresses by CBSA Status and Vendor
V = Valassis, CB = Consumer Base, MSG = Marketing Systems Group

	CDS CBSA Counties						*CDS Non-CBSA Counties*					
	V		*CB*		*MSG*		*V*		*CB*		*MSG*	
State/Area	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*
Alaska	11	0.2	25	0.3	20	0.3	9.7	0.4	13	0.4	11	0.4
Alabama	40	0.1	46	0.1	55	0.1	42	0.4	46	0.4	56	0.4
Jefferson County	41	0.3	49	0.3	56	0.3						
Rest of Alabama	39	0.1	45	0.1	54	0.1	42	0.4	46	0.4	56	0.4
Arkansas	31	0.1	39	0.2	43	0.2	34	0.3	39	0.3	47	0.3
Arizona	23	0.1	36	0.1	38	0.1	7.2	0.5	18	0.8	13	0.7
Maricopa County	24	0.1	37	0.1	40	0.1						
Rest of Arizona	22	0.1	33	0.1	36	0.2	7.2	0.5	18	0.8	13	0.7
California	25	0	38	0	42	0	28	0.5	33	0.5	41	0.6
Alameda County	26	0.2	39	0.2	45	0.2						
Fresno County	25	0.2	37	0.3	41	0.3						
Los Angeles County	24	0.1	35	0.1	40	0.1						
Northern Counties	29	0.3	39	0.3	46	0.3	30	0.7	35	0.7	42	0.7
Rest of California	26	0.1	40	0.1	44	0.1	27	0.7	31	0.8	40	0.8
San Bernardino County	24	0.2	36	0.2	40	0.2						
San Diego County	22	0.1	36	0.1	36	0.1						
Santa Clara County	26	0.2	42	0.2	46	0.2						
Colorado	31	0.1	42	0.1	48	0.1	30	0.4	41	0.4	45	0.4
City of Denver Counties	30	0.2	39	0.2	46	0.2						
Rest of Colorado	32	0.1	45	0.1	49	0.2	30	0.4	41	0.4	45	0.4

Connecticut	35	0.1	54	0.1	62	0.1						
District of Columbia	22	0.2	36	0.3	42	0.3						
Delaware	42	0.3	52	0.3	62	0.3						
Florida	30	0.1	43	0.1	47	0.1	38	0.4	44	0.4	53	0.4
Dade County	29	0.1	35	0.2	43	0.2						
Duval County	31	0.2	41	0.2	48	0.3						
Orange County	25	0.2	42	0.2	36	0.2						
Rest of Florida	31	0.1	44	0.1	48	0.1	38	0.4	44	0.4	53	0.4
Georgia	37	0.1	38	0.1	50	0.1	39	0.3	42	0.3	51	0.3
Fulton/DeKalb Counties	31	0.2	36	0.2	45	0.2						
Rest of Georgia	38	0.1	39	0.1	51	0.1	39	0.3	42	0.3	51	0.3
Hawaii	21	0.2	32	0.2	30	0.2	0	0	0	0	0	0
Iowa	37	0.2	49	0.2	54	0.2	46	0.3	55	0.3	66	0.3
Idaho	29	0.2	39	0.2	42	0.2	30	0.6	36	0.6	42	0.6
Illinois	32	0.1	45	0.1	50	0.1	33	0.3	42	0.3	50	0.3
Cook County	27	0.1	40	0.1	44	0.1						
Madison/St Clair Counties	39	0.3	50	0.3	57	0.3	48	10	48	10	67	9.8
Rest of Illinois	36	0.1	48	0.1	54	0.1	33	0.3	42	0.3	50	0.3
Indiana	36	0.1	46	0.1	54	0.1	37	0.4	46	0.4	58	0.4
Lake County	42	0.3	50	0.3	56	0.3						
Marion County	32	0.2	44	0.2	46	0.2						
Rest of Indiana	36	0.1	46	0.1	56	0.1	37	0.4	46	0.4	58	0.4
Kansas	33	0.1	45	0.2	51	0.2	42	0.4	46	0.4	60	0.4
Johnson/Wyandotte Counties	35	0.3	48	0.3	56	0.3						
Rest of Kansas	32	0.2	44	0.2	49	0.2	42	0.4	46	0.4	60	0.4
Kentucky	38	0.1	47	0.1	50	0.1	41	0.3	46	0.3	55	0.3
Louisiana	38	0.1	45	0.1	53	0.1	42	0.5	44	0.5	54	0.5
Massachusetts	41	0.1	52	0.1	60	0.1	28	1.2	43	1.3	51	1.3
Rest of Massachusetts	43	0.1	53	0.1	63	0.1	28	1.2	43	1.3	51	1.3
Suffolk County	23	0.2	38	0.3	42	0.3						
Maryland	40	0.1	44	0.1	57	0.1	44	0.9	48	0.9	59	0.9
Baltimore City	28	0.3	36	0.3	44	0.3						
Rest of Maryland	42	0.1	45	0.1	59	0.1	44	0.9	48	0.9	59	0.9
Maine	37	0.2	44	0.2	53	0.2	37	0.4	40	0.4	55	0.4
Michigan	38	0.1	48	0.1	54	0.1	40	0.3	46	0.3	55	0.3
Rest of Michigan	39	0.1	49	0.1	55	0.1	40	0.3	46	0.3	55	0.3
Wayne County	36	0.2	46	0.2	52	0.2						
Minnesota	38	0.1	48	0.1	58	0.1	45	0.3	56	0.3	65	0.3
Rest of Minnesota	41	0.2	53	0.2	60	0.2	45	0.3	56	0.3	65	0.3
Twin Cities Counties	36	0.1	46	0.1	56	0.1	43	3.5	47	3.5	60	3.5
Missouri	36	0.1	45	0.1	50	0.1	38	0.3	42	0.3	53	0.3
Rest of Missouri	35	0.1	44	0.1	50	0.1	38	0.3	42	0.3	53	0.3
St Louis County/City	37	0.2	48	0.2	51	0.2						
Mississippi	33	0.2	41	0.2	44	0.2	35	0.3	39	0.3	46	0.3
Montana	29	0.3	40	0.3	44	0.3	31	0.5	40	0.5	47	0.5
North Carolina	36	0.1	46	0.1	51	0.1	39	0.3	46	0.3	54	0.3
North Dakota	33	0.3	44	0.3	43	0.3	48	0.7	58	0.6	64	0.6
Nebraska	33	0.2	42	0.2	49	0.2	40	0.4	49	0.5	59	0.4
New Hampshire	40	0.2	50	0.2	62	0.2	37	1.3	46	1.3	60	1.3

New Jersey	36	0.1	49	0.1	55	0.1						
Essex County	26	0.2	45	0.3	46	0.3						
Rest of New Jersey	37	0.1	50	0.1	56	0.1						
New Mexico	27	0.2	33	0.2	40	0.2	24	0.8	25	0.8	32	0.9
Rest of New Mexico	27	0.2	35	0.2	41	0.2	28	1.2	26	1.2	36	1.3
Southern Counties	26	0.3	27	0.3	36	0.3	21	1.1	23	1.1	29	1.2
Nevada	21	0.1	34	0.1	31	0.1	22	1.1	32	1.2	35	1.2
Clark County	20	0.1	33	0.2	27	0.2						
Rest of Nevada	27	0.3	38	0.3	41	0.3	22	1.1	32	1.2	35	1.2
New York	29	0.1	40	0.1	50	0.1	31	0.4	36	0.4	50	0.4
City of New York Counties	21	0.1	33	0.1	45	0.1						
Rest of New York	35	0.1	46	0.1	53	0.1	31	0.4	36	0.4	50	0.4
Ohio	36	0.1	46	0.1	50	0.1	40	0.3	49	0.4	55	0.4
Cuyahoga County	34	0.2	43	0.2	48	0.2						
Franklin County	32	0.2	43	0.2	43	0.2						
Rest of Ohio	37	0.1	47	0.1	51	0.1	40	0.3	49	0.4	55	0.4
Oklahoma	35	0.1	40	0.1	46	0.1	27	0.3	27	0.3	36	0.3
Oregon	25	0.1	37	0.1	42	0.1	27	0.6	35	0.7	40	0.7
Pennsylvania	20	0.1	47	0.1	58	0.1	19	0.3	45	0.4	55	0.4
Allegheny County	16	0.2	50	0.2	58	0.2						
Philadelphia County	25	0.2	37	0.2	45	0.2						
Rest of Pennsylvania	20	0.1	48	0.1	60	0.1	19	0.3	45	0.4	55	0.4
Rhode Island	37	0.2	49	0.2	55	0.2						
South Carolina	35	0.1	45	0.1	48	0.1	43	0.5	50	0.5	55	0.5
South Dakota	37	0.3	47	0.3	52	0.3	49	0.6	57	0.6	65	0.6
Tennessee	36	0.1	47	0.1	52	0.1	42	0.3	49	0.3	56	0.3
Davidson County	29	0.3	44	0.3	46	0.3						
Rest of Tennessee	38	0.1	48	0.1	53	0.1	42	0.3	49	0.3	56	0.3
Shelby County	34	0.2	46	0.3	50	0.3						
Texas	31	0	39	0.1	43	0.1	34	0.2	37	0.2	45	0.2
Bexar County	30	0.2	42	0.2	42	0.2						
Dallas County	29	0.1	37	0.2	42	0.2						
El Paso County	31	0.3	37	0.3	42	0.3	0	0	0	0	33	26
Harris County	30	0.1	39	0.1	42	0.1	43	13	21	10	43	13
Rest of Texas	32	0.1	38	0.1	43	0.1	34	0.2	37	0.2	45	0.2
Utah	33	0.2	42	0.2	47	0.2	20	0.6	27	0.7	30	0.7
Virginia	39	0.1	47	0.1	53	0.1	42	0.3	48	0.3	56	0.3
Vermont	35	0.4	44	0.4	57	0.4	35	0.6	42	0.6	56	0.6
Washington	30	0.1	38	0.1	46	0.1	35	0.6	41	0.6	49	0.6
Eastern Counties	29	0.3	36	0.3	41	0.3	34	0.7	39	0.7	46	0.8
King County	28	0.2	38	0.2	44	0.2						
Rest of Washington	31	0.1	37	0.2	46	0.2	44	3.1	45	3.1	57	3.1
Western Counties	33	0.2	39	0.2	50	0.2	36	0.9	42	0.9	53	0.9
Wisconsin	39	0.1	48	0.1	58	0.1	43	0.3	47	0.3	65	0.3
Milwaukee County	33	0.2	45	0.2	50	0.2						
Rest of Wisconsin	41	0.1	49	0.1	60	0.1	43	0.3	47	0.3	65	0.3
West Virginia	32	0.2	35	0.2	44	0.2	24	0.3	22	0.3	37	0.4
Wyoming	26	0.3	42	0.4	36	0.4	33	0.7	46	0.7	45	0.7

Table 3: Phone Number Match Rates to Addresses by Address Type and Vendor
V = Valassis, CB = Consumer Base, MSG = Marketing Systems Group

	CDS City-Style						*CDS OWGM*					
	V		*CB*		*MSG*		*V*		*CB*		*MSG*	
State/Area	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*	*%*	*SE*
Alaska	11	0.2	25	0.3	20	0.3	8.4	0.4	11	0.5	9.2	0.4
Alabama	40	0.1	46	0.1	55	0.1	2.3	0.3	9.1	0.6	2.1	0.3
Jefferson County	42	0.3	49	0.3	56	0.3	3.6	1.4	9.6	2.2	1.8	1
Rest of Alabama	40	0.1	46	0.1	55	0.1	2.2	0.3	9.1	0.7	2.2	0.3
Arkansas	32	0.1	40	0.1	45	0.1	2	0.3	9.1	0.6	1.7	0.3
Arizona	24	0.1	36	0.1	40	0.1	1.4	0.1	9	0.3	1.6	0.1
Maricopa County	24	0.1	37	0.1	40	0.1	0	0	6.3	1.4	0	0
Rest of Arizona	24	0.1	35	0.2	39	0.2	1.4	0.1	9.1	0.3	1.7	0.1
California	25	0	38	0	42	0	3.4	0.2	13	0.3	4.3	0.2
Alameda County	26	0.2	39	0.2	45	0.2						
Fresno County	25	0.2	37	0.3	42	0.3	2.8	0.8	11	1.6	2.5	0.8
Los Angeles County	24	0.1	35	0.1	40	0.1	3.7	1.3	11	2.2	3.2	1.2
Northern Counties	31	0.3	40	0.3	47	0.3	4.9	0.6	12	0.8	6.1	0.6
Rest of California	27	0.1	40	0.1	44	0.1	3.2	0.2	13	0.4	4	0.3
San Bernardino County	25	0.2	36	0.2	41	0.2	3.3	0.4	16	0.8	4.4	0.5
San Diego County	22	0.1	36	0.1	36	0.1	0	0	14	5.5	5.6	3.6
Santa Clara County	26	0.2	42	0.2	46	0.2	0.7	0.7	14	2.9	1.4	1
Colorado	32	0.1	43	0.1	48	0.1	1.2	0.2	13	0.5	1.4	0.2
City of Denver Counties	30	0.2	39	0.2	46	0.2	2.5	1.4	13	3	1.7	1.1
Rest of Colorado	33	0.1	45	0.1	50	0.1	1.1	0.2	13	0.5	1.4	0.2
Connecticut	35	0.1	54	0.1	62	0.1	0.9	0.3	5.5	0.7	1.4	0.4
District of Columbia	22	0.2	36	0.3	42	0.3						
Delaware	43	0.3	53	0.3	63	0.3	1.8	0.7	7.6	1.4	2.9	0.9
Florida	31	0.1	43	0.1	47	0.1	1.7	0.2	9.5	0.4	1.6	0.2
Dade County	29	0.1	35	0.2	43	0.2						
Duval County	31	0.2	41	0.2	48	0.3						
Orange County	25	0.2	42	0.2	36	0.2	1.3	0.7	11	2	0	0
Rest of Florida	31	0.1	45	0.1	49	0.1	1.7	0.2	9.4	0.4	1.6	0.2
Georgia	37	0.1	39	0.1	50	0.1	2	0.3	7.7	0.5	1.3	0.2
Fulton/DeKalb Counties	31	0.2	36	0.2	45	0.2	1.5	0.7	12	1.9	0.4	0.4
Rest of Georgia	38	0.1	39	0.1	52	0.1	2.1	0.3	7.3	0.5	1.4	0.2
Hawaii	21	0.2	33	0.2	31	0.2	7.1	0.6	16	0.8	6.8	0.6
Iowa	40	0.1	51	0.1	57	0.1	1.5	0.4	7.6	0.8	1.3	0.3
Idaho	29	0.2	39	0.2	42	0.2	2	0.5	9.6	1	2.7	0.6
Illinois	33	0.1	45	0.1	50	0.1	2.3	0.3	9.3	0.5	2	0.3
Cook County	27	0.1	40	0.1	44	0.1	1.1	0.7	7.2	1.8	0	0
Madison/St Clair Counties	39	0.3	50	0.3	57	0.3	0.6	0.6	10	2.2	1.2	0.8
Rest of Illinois	36	0.1	48	0.1	54	0.1	2.5	0.3	9.3	0.6	2.2	0.3
Indiana	36	0.1	47	0.1	55	0.1	2.3	0.3	8.2	0.6	1.9	0.3
Lake County	42	0.3	50	0.3	56	0.3	1.9	1.8	7.4	3.4	0	0
Marion County	32	0.2	44	0.2	46	0.2	0	0	15	9.5	0	0
Rest of Indiana	37	0.1	47	0.1	57	0.1	2.3	0.3	8.2	0.6	2	0.3
Kansas	34	0.1	45	0.1	52	0.1	3.5	1.1	10	1.7	3.9	1.1
Johnson/Wyandotte Counties	35	0.3	48	0.3	56	0.3						

Rest of Kansas	34	0.2	44	0.2	51	0.2	3.5	1.1	10	1.7	3.9	1.1
Kentucky	39	0.1	48	0.1	52	0.1	2	0.3	7.4	0.6	2.2	0.3
Louisiana	39	0.1	46	0.1	53	0.1	1	0.2	8.9	0.5	1.1	0.2
Massachusetts	41	0.1	52	0.1	61	0.1	2.2	0.2	6.4	0.4	2.7	0.2
Rest of Massachusetts	44	0.1	54	0.1	64	0.1	2.2	0.2	6.4	0.4	2.7	0.2
Suffolk County	23	0.2	38	0.3	42	0.3						
Maryland	41	0.1	44	0.1	58	0.1	2.2	0.4	8.1	0.7	2.2	0.4
Baltimore City	28	0.3	36	0.3	44	0.3						
Rest of Maryland	42	0.1	45	0.1	60	0.1	2.2	0.4	8.1	0.7	2.2	0.4
Maine	38	0.2	44	0.2	55	0.2	6.3	0.6	9	0.7	6.2	0.6
Michigan	39	0.1	48	0.1	55	0.1	1.4	0.2	6.4	0.5	1.3	0.2
Rest of Michigan	39	0.1	49	0.1	55	0.1	1.4	0.2	6.4	0.5	1.3	0.2
Wayne County	36	0.2	46	0.2	52	0.2						
Minnesota	39	0.1	50	0.1	59	0.1	4.3	0.6	9.7	0.8	3.2	0.5
Rest of Minnesota	43	0.2	54	0.2	62	0.2	4.5	0.6	9.8	0.9	3.3	0.5
Twin Cities Counties	36	0.1	46	0.1	56	0.1	0	0	7.9	3.2	0	0
Missouri	36	0.1	46	0.1	51	0.1	3.1	0.5	9.7	0.8	3.3	0.5
Rest of Missouri	36	0.1	45	0.1	51	0.1	3.1	0.5	9.7	0.8	3.3	0.5
St Louis County/City	37	0.2	48	0.2	51	0.2						
Mississippi	34	0.1	41	0.1	45	0.1	1.6	0.2	8.5	0.5	1.7	0.2
Montana	30	0.2	42	0.3	46	0.3	6.2	0.7	9.3	0.8	6.3	0.7
North Carolina	36	0.1	46	0.1	51	0.1	1.7	0.2	8.5	0.4	1.8	0.2
North Dakota	36	0.3	47	0.3	48	0.3	3.2	1.7	20	4	2.1	1.4
Nebraska	34	0.2	43	0.2	51	0.2	3.4	1.3	4.6	1.5	3.4	1.3
New Hampshire	41	0.2	51	0.2	63	0.2	3.6	0.7	11	1.1	6.5	0.9
New Jersey	36	0.1	50	0.1	55	0.1	1.4	0.2	7.7	0.5	1.1	0.2
Essex County	26	0.2	45	0.3	46	0.3						
Rest of New Jersey	37	0.1	50	0.1	56	0.1	1.4	0.2	7.7	0.5	1.1	0.2
New Mexico	28	0.2	34	0.2	41	0.2	3.6	0.3	8.8	0.5	3.8	0.3
Rest of New Mexico	28	0.2	36	0.2	43	0.2	4.1	0.5	13	0.8	4.2	0.5
Southern Counties	27	0.3	29	0.3	38	0.3	3	0.5	4.2	0.5	3.2	0.5
Nevada	22	0.1	35	0.1	32	0.1	4.6	0.5	13	0.7	5.4	0.5
Clark County	20	0.1	33	0.2	28	0.2	2.8	0.9	14	1.8	3.4	1
Rest of Nevada	28	0.3	40	0.3	43	0.3	5	0.5	12	0.8	5.8	0.6
New York	29	0.1	41	0.1	50	0.1	2.9	0.2	7.9	0.3	3.5	0.2
City of New York Counties	21	0.1	33	0.1	45	0.1						
Rest of New York	36	0.1	47	0.1	54	0.1	2.9	0.2	7.9	0.3	3.5	0.2
Ohio	36	0.1	47	0.1	50	0.1	1.8	0.2	8.5	0.4	2	0.2
Cuyahoga County	34	0.2	43	0.2	48	0.2						
Franklin County	32	0.2	43	0.2	44	0.2	1.1	1.1	8	2.8	0	0
Rest of Ohio	37	0.1	48	0.1	52	0.1	1.8	0.2	8.5	0.4	2	0.2
Oklahoma	35	0.1	40	0.1	46	0.1	5.6	0.5	14	0.7	5.5	0.5
Oregon	25	0.1	37	0.1	42	0.1	2.5	0.5	11	1	2.7	0.5
Pennsylvania	21	0.1	48	0.1	59	0.1	2.3	0.1	11	0.3	5.5	0.2
Allegheny County	16	0.2	50	0.2	58	0.2	1.2	0.6	7.5	1.6	1.6	0.7
Philadelphia County	25	0.2	37	0.2	45	0.2						
Rest of Pennsylvania	21	0.1	49	0.1	61	0.1	2.3	0.1	11	0.3	5.6	0.2
Rhode Island	37	0.2	50	0.2	55	0.2	0.7	0.4	7	1.4	1.7	0.7
South Carolina	36	0.1	46	0.1	49	0.1	0.8	0.2	6.9	0.6	0.7	0.2
South Dakota	40	0.3	49	0.3	55	0.3	9.2	1.8	22	2.5	11	1.9

Tennessee	37	0.1	48	0.1	52	0.1	1.2	0.3	7.3	0.7	1.1	0.3
Davidson County	29	0.3	44	0.3	46	0.3						
Rest of Tennessee	38	0.1	49	0.1	54	0.1	1.2	0.3	7.1	0.7	1.1	0.3
Shelby County	34	0.2	46	0.3	50	0.3	0	0	11	3.7	0	0
Texas	31	0	39	0.1	43	0.1	3.2	0.2	10	0.3	3.4	0.2
Bexar County	30	0.2	42	0.2	42	0.2	0	0	4.2	3.9	0	0
Dallas County	29	0.1	37	0.2	42	0.2						
El Paso County	31	0.3	38	0.3	42	0.3	1.9	0.7	8.5	1.3	2.9	0.8
Harris County	30	0.1	39	0.1	42	0.1	0.6	0.6	11	2.3	0	0
Rest of Texas	32	0.1	39	0.1	44	0.1	3.3	0.2	10	0.3	3.5	0.2
Utah	33	0.2	42	0.2	47	0.2	1.8	0.3	12	0.7	2.2	0.3
Virginia	39	0.1	47	0.1	54	0.1	4	0.4	8.7	0.5	4.7	0.4
Vermont	36	0.3	45	0.3	59	0.3	5.2	0.8	11	1.1	7.1	0.9
Washington	31	0.1	38	0.1	46	0.1	4	0.4	11	0.6	4.1	0.4
Eastern Counties	30	0.3	37	0.3	43	0.3	3.4	0.6	10	1.1	3.8	0.7
King County	28	0.2	38	0.2	44	0.2	4.9	1.7	15	2.9	1.4	0.9
Rest of Washington	31	0.1	37	0.2	47	0.2	4.7	0.9	12	1.4	4.1	0.9
Western Counties	34	0.2	40	0.2	51	0.2	3.9	0.5	11	0.8	4.5	0.6
Wisconsin	40	0.1	48	0.1	60	0.1	2.4	0.4	9	0.8	2.8	0.4
Milwaukee County	33	0.2	45	0.2	50	0.2						
Rest of Wisconsin	41	0.1	49	0.1	62	0.1	2.4	0.4	9	0.8	2.8	0.4
West Virginia	35	0.2	38	0.2	48	0.2	7.7	0.4	13	0.5	7	0.4
Wyoming	29	0.3	44	0.4	40	0.3	1.8	0.5	12	1.2	1.5	0.4

4. Discussion

The figures and tables in Section 3 show that the phone number match rates vary considerably by vendor, by geographic area, and by address type. In general, MSG's landline match rate with multiple sources exceeds Valassis' landline match rate, which, in turn, exceeds Consumer Base's landline match rate. Consumer Base provides some cell phone matches, which neither Valassis nor MSG provides. With the cell numbers, Consumer Base's match rate exceeds Valassis' rate. Users may want to obtain phone numbers from multiple vendors to maximize the match rate.

One limitation in this research is the time factor. Ideally the vendors would have provided phone flags for the same point in time, very close to the date of the address file. While the address file was from February 2012, and the Valassis phone flag was from the same period, the Consumer Base match was conducted in July 2012, and the MSG match was conducted in September 2012. Therefore, the vendor differences in this paper include timing effects as well as data source and match methodology effects.

We obtained only the flag indicators for the availability of a telephone number from a vendor rather than the actual telephone numbers. The primary reason was cost. The flags cannot be used to contact households, but they are low cost for research of this nature. Even if we had the telephone numbers, contacting them to validate the numbers would have been prohibitively expensive for a sample of this

size. Perhaps a much smaller sample of numbers from the flagged addresses could be obtained and called for validation. This is essentially what was done by McMichael et al. (2012), using an actual study sample. Estimating the rate of *valid* telephone numbers is the critical next step in understanding the extent to which phone numbers can be used to collect data by telephone for an address-based sample.

Telephone numbers change much more rapidly than addresses. Households move or change telephone service, often making their prior telephone numbers obsolete, at least for the address to which it was matched. Furthermore, vendors are not necessarily on the same update schedule for either the address or telephone files. Consequently, the results of this research are very transitory in nature and should be updated periodically. However, this snapshot is intended to provide a key piece of information in planning ABS mixed mode surveys—the estimated telephone match rate—especially for sub-national geographies.

Acknowledgements

The authors thank Consumer Base and Marketing Systems Group for their assistance in conducting this research.

References

Blumberg, S., and Luke, J. (2012) ‘‘Wireless Substitution: Early Release of Estimates from the National Health Interview Survey July–December 2011.” National Center for Health Statistics. http://www.cdc.gov/nchs/nhis.htm.

Blumberg, S., and Luke, J. (2009) ‘‘Reevaluating the Need for Concern Regarding Noncoverage Bias in Landline Surveys.” *American Journal of Public Health* 99(10), 1806-10.

Iannacchione, V. G. (2011) The changing role of address-based sampling in survey research. *Public Opinion Quarterly*, *75*(3), 556–575. http://poq.oxfordjournals.org/.

Iannacchione, V., Staab, J., and Redden, D. (2003) ‘‘Evaluating the Use of Residential Mailing Lists in a Metropolitan Household Survey.’’ *Public Opinion Quarterly* 67(2), 202–10.

McMichael, J. and Roe, D. (2012) “ABS and Cell Phones: Appending Both Cell Phone and Landline Phone Numbers to an Address-Based Sampling Frame.” Presented at the Joint Statistical Meetings, July 30, San Diego.

McMichael, J. Harter, R., Shook-Sa, B., and Iannacchione, V. (2012) “Sub-National Coverage Profile of U.S. Housing Units Using the USPS Computerized Delivery Sequence File.” Presented at the American Association of Public Opinion Research Conference, May 18, Orlando.

Murphy, W., Harter, R., and Xia, K. (2010) “Design and operational changes for REACH U.S.” Proceedings of the Section on Survey Research Methods, American Statistical Association, 332–342.

Office of Management and Budget (2000). “Standards for Defining Metropolitan and Micropolitan Statistical Areas,” Federal Register, Part IX, December 27, 2000. http://www.whitehouse.gov/sites/default/files/omb/fedreg/metroareas122700.pdf .

O’Muircheartaigh, C., Eckman, S., and Weiss, C. (2003) ‘‘Traditional and Enhanced Field Listing for Probability Sampling.’’ *Proceedings of the American Statistical Association, Section on Survey Research Methods*, 2563–67.

Shook-Sa, B., Currivan, D., McMichael, J., and Iannacchione, V. (2012) “Beyond the USPS CDS File: Extending the Coverage of ABS Frames” Presented at the Joint Statistical Meetings, Aug 1, San Diego.