A PROPOSED HYBRID SAMPLING FRAME FOR THE NATIONAL SURVEY ON DRUG USE AND HEALTH

FINAL REPORT

Contract No. 283-2004-00022
RTI Project No. 0209009

Authors:

Vincent G. Iannacchione
Joseph P. McMichael
Bonnie E. Shook-Sa
Katherine B. Morton

Project Director:

Thomas G. Virag

Prepared for:

Substance Abuse and Mental Health Services Administration
Rockville, Maryland 20857

Prepared by:

RTI International
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Abstract

The target population for the National Survey on Drug Use and Health (NSDUH) is the civilian, noninstitutional population of the United States aged 12 or older. Currently, the NSDUH sampling frame relies on field enumeration (FE) to identify dwelling units (DUs) that are eligible for selection. The half-open interval (HOI) frame-linking procedure is designed to cover DUs that are missed during FE. The proposed hybrid sampling frame would use address-based sampling (ABS) as a frame for the vast majority of NSDUH segments, but would still rely on FE and the HOI procedure for the remaining (primarily rural) segments where ABS coverage is low. The Check for Housing Units Missed (CHUM) procedure would be used to cover missed DUs in ABS segments (see Section 3 for details).

This report summarizes research conducted by RTI to evaluate the coverage, cost, and implementation of the proposed hybrid sampling frame for NSDUH. Topics include results from the Mailing List Field Studies (MLFS) I and II, subsequent work developing and testing the CHUM procedure, and exploratory analyses on coverage prediction, group quarters coverage, geocoding error, and potential supplemental sources of addresses.

Major research findings include the following:

Coverage of the hybrid frame

- Theoretically, the hybrid frame provides 100 percent coverage of the target population. In FE segments, the coverage is equivalent to the current NSDUH coverage rate. In ABS segments, DUs that are not included on the ABS frame are covered by the CHUM procedure. The only known sources of under-coverage occur when field staff incorrectly implement the CHUM and/or HOI procedures.
- The ABS coverage threshold is defined for each segment as the ratio of the number of DUs with locatable mailing addresses[1] to the total number of DUs in the segment. Segments that meet or exceed a specified coverage threshold will be assigned to ABS; otherwise, they will be assigned to FE. ABS coverage thresholds of 50, 65, or 80 percent respectively would require that approximately 8, 14, or 27 percent of NSDUH segments be assigned to FE (see Section 5.1 for details).
- ABS coverage of group quarters (GQs) is problematic. Therefore, segments with high concentrations of GQs should be allocated to FE whenever possible. The 2010 Decennial Census is the only feasible source for predefining segments requiring FE based on having a large noninstitutional GQs population. However, as the data age, the quality of the predictor will deteriorate (see Section 5.2 for further details).
- *Geocoding error* occurs when the geographic coordinates assigned to a DU do not correspond to its actual location. Without a frame supplementation procedure like the CHUM, geocoding error can lead to both over-coverage error and under-coverage error of an ABS frame. It is more problematic in rural areas than urban areas, and for area segments comprised of smaller levels of census geography (see Section 5.3 for further details).

[1] A locatable mailing address has a street name and number, unit number if appropriate, city, state, and ZIP Code.

Cost savings of the hybrid frame

- The cost savings afforded by the hybrid frame depend on how many segments are assigned to ABS. In general, the lower the ABS coverage threshold, the more segments will be allocated to ABS and the higher the cost savings. However, because the CHUM procedure is designed to supplement areas with adequate ABS coverage, it is more efficient to allocate segments with very low ABS coverage to the FE frame (see Section 4.1.2 for further details).
- Cost savings are also a function of how well ABS coverage is predicted at the segment level. Inefficiencies arise when segments are allocated to FE that should be allocated to ABS and when segments are allocated to ABS that should be allocated to FE (because the high reliance on the CHUM procedure mitigates the cost savings of ABS). For a further discussion of how coverage prediction affects the costs of the hybrid frame, see Section 4.1.2.

Implementation of the CHUM procedure

- The CHUM procedure is an ABS frame-supplementation procedure. The CHUM is implemented by field staff from selected DUs to pick up any DUs that are not included on the ABS frame. When implemented correctly, it gives every DU in a sampled segment a chance of selection with known probability. The implementation of the CHUM procedure is discussed further in Section 3.
- ABS frames supplemented with the CHUM procedure provide 100 percent coverage of the target population when the CHUM is implemented correctly. We conducted a field study (MLFS II) to measure how well field staff implement the CHUM procedure in various situations they are likely to encounter in the field. The success rate for typical CHUM intervals[2] was 90.7 percent compared with 60.0 percent for high-difficulty intervals. Section 4.2 provides further details about the experimental design and the results of the MLFS II.
- To ensure correct implementation of the CHUM procedure, field staff must receive adequate training. The at-home training combined with in-person training that was used on the MLFS II was generally effective. (see Section 4.2 for further details); however, during fieldwork, FIs reported difficulty with several concepts such as performing the CHUM at apartments and trailer parks and knowing when to contact field support for assistance. As a result, improved training procedures and materials are needed.
- After training, FIs must be monitored in the field through the use of seeding and other techniques to ensure they are correctly implementing the CHUM procedure. They must also be provided with field support to answer questions that arise while implementing the CHUM procedure in the field (see Section 4.2 for further discussion).

With proper training and monitoring, the hybrid sampling frame can be implemented in a way that reduces survey costs while maintaining the high scientific standards of the NSDUH. Further efficiencies can be gained by developing techniques that accurately allocate segments with low ABS coverage (e.g., segments with high concentrations of GQs) to the FE frame, and by continuing to explore sources of supplemental addresses.

[2] Implementation of the CHUM interval specifies that a field interviewer first face a sampled DU and then proceed clockwise around the block, without crossing a street, to find the next DU.

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1. Introduction

Address-based sampling (ABS) is increasingly viewed as a potential remedy for the rising costs associated with in-person surveys of the U.S. general population. In fact, ABS has become an integral component of the sampling frames of such well-established in-person household surveys as the National Survey of Family Growth (Lepkowski et al., 2010), the American National Election Study (Lupia, Krosnick, Luevano, DeBell, & Donakowski, 2009), and the General Social Survey (Harter et al., 2010).

Each of these surveys uses ABS in different ways. For example, the sampling frame for the 2008 American National Election Study (ANES) was based entirely on ABS and the Check for Housing Units Missed (CHUM) frame-linking procedure. To control data collection costs, census block groups with fewer than 20 city-style addresses were excluded from the sampling frame. Based on Census projections, these exclusions accounted for approximately 0.8 percent of the households in the ANES target population. The use of the CHUM methodology in sampled ABS segments increased the coverage of the target population by approximately 5.1 percentage points. When combined, the ABS frame and the CHUM accounted for between 84 and 94 percent (95% confidence interval) of the 116.2 million households in the 48 coterminous states and the District of Columbia reported by the 2008 Current Population Survey (CPS). The sampling weights were poststratified to CPS estimates to reduce the potential bias that may result from the under-representation of the households excluded from the ABS frame and the CHUM.

Like the proposed hybrid sampling frame for the NSDUH, the 2004, 2006, and 2008 General Social Survey (GSS) was based on ABS in segments where ABS coverage was predicted to be high and on field enumeration (FE) elsewhere (Harter et al., 2010). The prediction was based on the U.S. Census Bureau's Type of Enumeration Area (TEA) code, which describes the quality of mailing addresses in each block (U.S. Census Bureau, 2011a). Blocks with a TEA value of one indicated that the block contained addresses that were suitable for mail-out and mail-back of the 2000 census form. Because GSS segments were larger than blocks, a segment was assigned to ABS if 95 percent of the segment population was in blocks with a TEA code equal to one. No field checks for missed housing units were done for the 86 percent of segments on the national frame assigned to ABS because updated address listings were obtained shortly before sample selection.

The segment lists for the 2006–2010 National Survey of Family Growth came from three sources. In about 35 percent of the segments, unused FE listings from the 2002 survey were used. Although ABS lists were obtained for the remaining 65 percent of segments, not all of the lists could be efficiently used. FE was done by interviewers in 15 percent of segments where the number of addresses was too low for subsequent field checking. Sufficient address counts were obtained for the remaining 50 percent of segments. The addresses in these segments were sent for field updating by the interviewers. An experimental study by Eckman and Kreuter (2011) found that a list updating process can be vulnerable to *confirmation bias*, which is the tendency for interviewers to make failure-to-add and failure-to-delete errors on a list to be updated.

Although each of these surveys uses ABS differently, each is concerned with the trade-offs between cost savings and coverage. Similarly, the cost savings afforded by the use of ABS over FE for the NSDUH are tempered by research indicating that FE provides more complete coverage than ABS, especially in rural areas. RTI developed and piloted a hybrid sampling frame for the NSDUH that uses ABS supplemented with the CHUM frame-linking procedure in area segments with adequate ABS coverage, but retains FE in segments where poor ABS coverage is anticipated. This report addresses the trade-offs between coverage and cost savings as area segments are shifted from FE to ABS.

2. Implementation of the Hybrid Sampling Frame

The proposed hybrid sampling frame for the NSDUH is designed to produce significant cost savings without sacrificing the coverage of the current NSDUH sampling frame, which is based exclusively on FE supplemented with the half-open interval (HOI) frame-linking procedure (Kish, 1965).

The current NSDUH sample design is implemented with a five-step process:

1. Stratify each State into a specified number of regions.
2. Select census tracts within regions.
3. Select segments (which are a collection of adjacent census blocks) within sampled census tracts.
4. Select dwelling units (DUs) within sampled segments.
5. Select 0, 1, or 2 persons within sampled DUs.

Steps 1, 2, and 3 are completed using data readily available electronically from the U.S. Census Bureau and other sources. However, before step 4 can be completed, field staff (called "listers") physically travel to the sampled segments to field enumerate all DUs in each sampled segment. Each NSDUH segment comprises one or more adjacent census blocks that, in combination, meet or exceed the minimum requirement of 100 DUs in rural areas or 150 DUs in urban areas. The enumeration data are used by statisticians to select a sample of DUs. Field interviewers (FIs) visit sampled DUs in person where a screening is conducted to determine if 0, 1, or 2 persons will be selected for the NSDUH interview. Before the FI leaves each selected DU, units that may not have been documented by the lister are identified using the HOI.

The hybrid frame relies on an ABS list that consists of a predetermined list of locatable city-style addresses[3] based on the Computerized Delivery Sequence (CDS) and No-Stat files maintained by the U.S. Postal Service (USPS 2011). The basic data elements of a mailing address include: street/box number, city, state, nine-digit ZIP Code, carrier route number,[4] and the delivery-sequence number that corresponds to the order in which a letter carrier delivers mail. In addition, the mailing record includes a USPS vacant address indicator flag for city-style addresses, and a seasonal flag for seasonal delivery. Seasonal and vacant flags are assigned at the discretion of the local post office using internal postal guidelines.[5] The No-Stat file supplements the CDS file with (1) addresses on rural and highway contract carrier routes that have been vacant for 90 days or longer, (2) locatable city-style addresses for PO Box throwbacks[6] on rural

[3] A locatable city-style mailing address has a street name and number, unit number if appropriate, city, state, and ZIP Code.

[4] The four carrier route designations are city (C), rural (R), highway contract (H), general delivery (G), and PO box (B).

[5] USPS guidelines specify that a vacant address is an address that has been unoccupied for 90 days or more.

[6] A throwback address is a locatable, city-style address where residents elect to receive mail at PO Boxes rather than at their residences.

and highway contract carrier routes, (3) locatable city-style addresses for drop units including unit type and number (e.g., APT 14), and (4) addresses of residences under construction.

The ABS list is supplemented with the CHUM frame-linking procedure to identify and record DUs that are not included on the ABS list (McMichael, Ridenhour, & Shook-Sa, 2008). The ABS-based frame is not expected to completely replace the current FE-based frame. FE and the HOI procedure will be retained in segments where ABS coverage is expected to be low. Research from prior studies (e.g., Iannacchione et al., 2007; O'Muircheartaigh, English, & Eckman, 2007), indicates that rural areas are more likely to have low ABS coverage than urban areas. Note that an overlapping sample of segments similar to the current NSDUH frame also would be used for the hybrid frame.

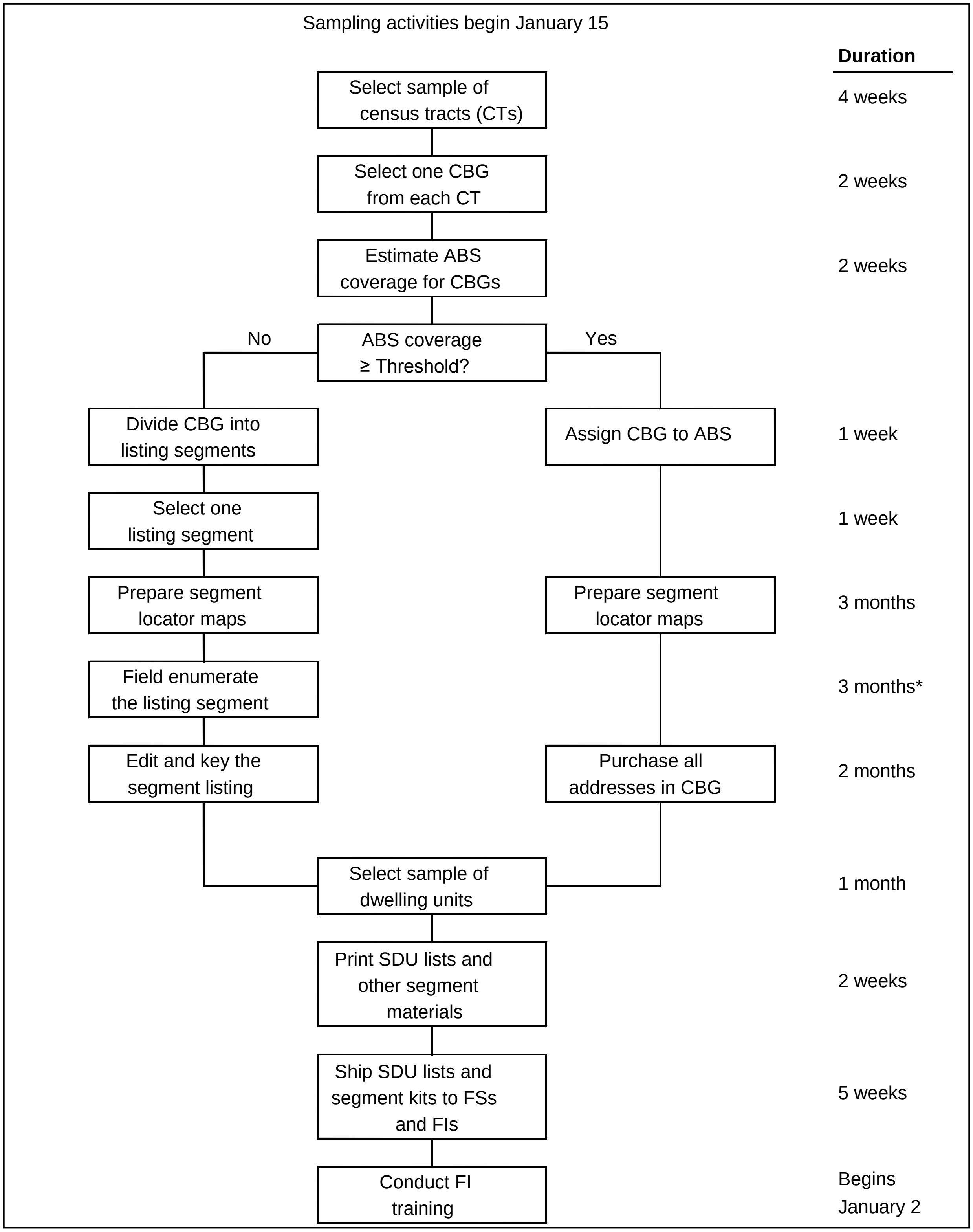
Operationally, the hybrid sampling frame would be implemented as follows:

1. Select the sample of segments.
2. Obtain estimates of the number of locatable city-style mailing addresses and the number of DUs in each sampled segment.
3. Estimate the expected ABS coverage rate for each sampled segment. The current method for estimating this rate is the ratio of the number of city-style mailing addresses on the ABS list in a segment to the estimated number of DUs in the segment.
4. Compare the expected ABS coverage rate to a predetermined coverage threshold. The ABS list supplemented with the CHUM procedure will serve as the frame for segments with coverage rates at or above the threshold. All other segments will be scheduled for FE supplemented with the HOI procedure.

A review of the ABS coverage predictions would be made each year. ABS segments that have an excessive number of missed DUs picked up by the CHUM would be reassigned to FE for the following year. An operational flow chart for implementing the hybrid frame is shown in Figure 1. Note that sampling activities for the current NSDUH sampling design usually begin in October of the previous year, that is, 15 months before the start of data collection.

The additional stage of sample selection for FE segments affects the assignment of variance replicates for estimating sampling variances. For FE segments, the listing segment would be the variance replicate as is currently done for NSDUH. For ABS segments, the variance replicate would be the census block group. For both FE and ABS segments, the variance estimation strata would be the State sampling region.

Figure 1. Operational Flow Chart for the Hybrid Frame



ABS = address-based sampling; CBG = census block group; CT = Census Tract; FI = field interviewer; FS = field supervisor; SDU = sample dwelling unit.

Note: Some activities can be started before the previous activity is completed. For example, the editing and keying of segment listings can begin before field enumeration is completed. This assumes 3,600 new segments will be selected each year and 3,600 will be retained from the prior year's sample.

* Assumes approximately 720 primarily rural segments will be field enumerated each year.

3. Implementation of the CHUM Frame-Linking Procedure

The CHUM procedure is designed to be used in segments where ABS coverage is incomplete but not low enough to require field enumeration. As Figure 2 demonstrates, the CHUM procedure uses two components to supplement the coverage of an ABS frame. The CHUM1 component enables FIs to establish a *path of travel* from the sampled DU to the next DU. This methodology requires segments with discernible boundaries so that DUs can be identified as being within a sampled segment. Facing the located sampled DU, the FI travels clockwise around the block, without crossing a street, to find the next DU. Street crossings are avoided to ensure that each path of travel is non-overlapping.

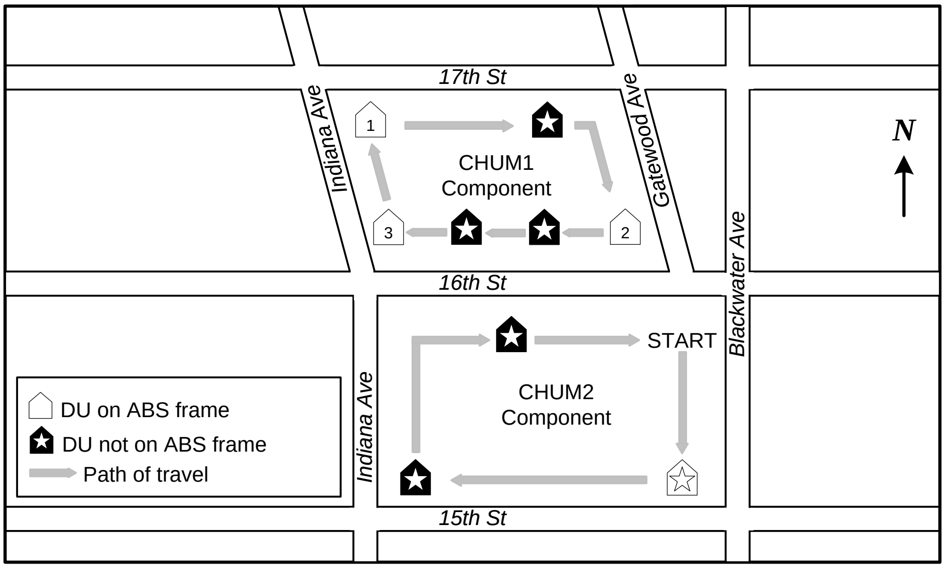
After the address of the next DU is found, it is checked against the ABS frame to determine whether it was missed. This check requires access to the entire ABS frame within each selected segment. If the address of the next DU is not on the ABS frame, the DU is sampled and assigned a probability of selection that is linked to the probability of selecting the sampled DU. If multiple missed DUs are picked up by the CHUM1, then subsampling may be used to control the sample size. Otherwise, a missed DU is included in the sample and assigned the same design weight as the sampled DU. This step is repeated until either the address of a DU on the ABS frame is found or the block is circumnavigated.

Because CHUM1 is restricted to blocks associated with a sampled address, DUs in blocks with no addresses on the ABS frame will be missed. CHUM2 mitigates this source of under-coverage by adding the "missed blocks" and their associated DUs to the frame. FIs perform the CHUM2 procedure from a predetermined start point in a randomly selected area rather than a starting DU. The FIs follow the same path of travel that they do for the CHUM1 procedure, stopping when they either list an address that matches to the ABS list or they return to the start point without finding a match. This procedure enables coverage of DUs that are in blocks where none of the DUs are on the ABS list. For segments that contain multiple missed blocks, efficient sampling methods can be used to select a subsample of missed DUs.

The CHUM procedure was developed for use in ABS segments. However, if the proposed hybrid frame is implemented without changes, FIs and field support staff would be faced with learning the HOI procedure for use in FE segments and the CHUM procedure for use in ABS segments. Simultaneously implementing two distinct procedures would have both cost and quality implications. In this section, we describe two options for using only the CHUM procedure to supplement the coverage of the hybrid frame.

Option 1: Use GPS methodology to implement the CHUM. Not doing the HOI or the CHUM in FE segments would eliminate the need to revise the existing CHUM methodology, which was developed for use in ABS segments. However, if Global Positioning System (GPS) devices were available for use on NSDUH, the CHUM methodology could be revised for use in FE as well as ABS segments.

Figure 2. Examples of CHUM Components



CHUM1 Component: Path of travel moves clockwise from the selected DU. If DU 1 is selected, one missed DU would be added to the ABS frame. If DU 2 is selected, two missed DUs would be added. No missed DUs would be added if DU 3 is selected. **CHUM2 Component**: First, a block or area is randomly selected within a segment. Then FIs are provided a segment map that enables the entire block to be field enumerated. In this case, three missed DUs are added to the frame. Notice that the three missed DUs have no chance for inclusion solely using CHUM1.

The primary obstacle for implementing the CHUM in FE segments is the handling of descriptive addresses. Listing units with descriptive addresses (e.g., red brick house on the corner of Main and Elm) are problematic for the CHUM procedure because they cannot be matched to mailing addresses on the iPAQ device which is currently used for screening SDUs. In 2007, approximately 6.4 percent of the SDUs in NSDUH rural segments had descriptive addresses (Morton et al., 2007). This is our best estimate for what FIs would encounter when implementing the CHUM in FE segments because rural segments are more likely to fall below the ABS coverage threshold and thus would require FE.

The use of GPS methodology would entail the development of a revised CHUM protocol that could be used in either FE or ABS segments, along with the acquisition of GPS devices and the development of computer programs for using the devices. In FE segments, listers would use the GPS devices to capture the latitude, longitude, and either the street name and number or the DU description of each listing unit. In ABS segments, geocoded latitudes and longitudes would be purchased along with the mailing addresses.

During data collection, FIs would first use the GPS device to locate the SDU. When implementing the CHUM from the SDU, the device would display a predetermined number of DUs that are closest to the SDU. For ABS segments, the device would display the street addresses of nearby DUs. For FE segments, the device would display the street addresses and/or descriptive addresses of nearby DUs. The FI would then locate the next DU in the path of travel by proceeding clockwise around the block and either select one of the displayed DUs or a “not on list” option where they would enter the address and capture its GPS coordinates. Note that the path of travel is identical in both ABS and FE segments. FIs would not need to search through addresses known to be in a different part of the segment. In addition, the device could alert the FI when he or she has traveled beyond the segment boundary.

To fully utilize GPS methodology, the current listing procedure would need to be revised to include a uniform protocol for capturing the GPS coordinates of listing units in FE segments. The CHUM procedure would also need to be revised to include the capture of GPS coordinates of missed DUs. These revisions and the acquisition of appropriate GPS devices would require start-up resources. Given the estimated cost savings associated with the use of the hybrid frame, however, the start-up costs associated with the use of GPS technology would likely be quickly recouped.

Option 2: Discontinue the HOI in FE segments and use existing software to implement the CHUM in ABS segments. Until GPS devices are available for the NSDUH, we recommend that the HOI be dropped in FE segments and that the existing CHUM methodology be used in ABS segments. Even if the HOI procedure were discontinued in FE segments, the current practice of asking about other DUs on the premises of the sample dwelling unit (SDU) (e.g., an apartment above the garage) as part of the screening would be retained (RTI International, 2011). To corroborate this option, we examined the addresses of all 381 added DUs in Quarter 4 2010, and found that 272 (71.4 percent) were added as a result of the FI asking the screening respondent about additional units in or around the SDU. The remaining 109 added DUs were found within the HOI and were either new construction or were missed during FE. This implies that searching the HOI itself accounted for only 0.002 of the 48,568 SDUs selected for the quarter.

The existing CHUM procedure can be implemented in ABS segments on the iPAQs (or other screening device), and the CHUM training materials developed for the Mailing List Field Study (MLFS) II can be used with minor modifications (see Section 4.2 for details). The iPAQ ABS search software, developed for the MLFS I and used for both the MLFS I and the MLFS II, does not require FIs to enter complete addresses into the iPAQ in order to search for them, and it is not case sensitive. The software contains search fields for "Street #" and "Street Name"; FIs can enter values into either of these fields.

Figure 3 presents an example in which the FI performs the CHUM procedure from the SDU "16 Elliott Ave." The FI identifies the next DU as "61 Dan Ave." Instead of entering the entire address into the iPAQ, the FI enters only "Dan" into the "Street Name" field and searches for all addresses in the segment that have street names containing "Dan." The FI can then examine the list and see that "61 Dan Ave" is included.

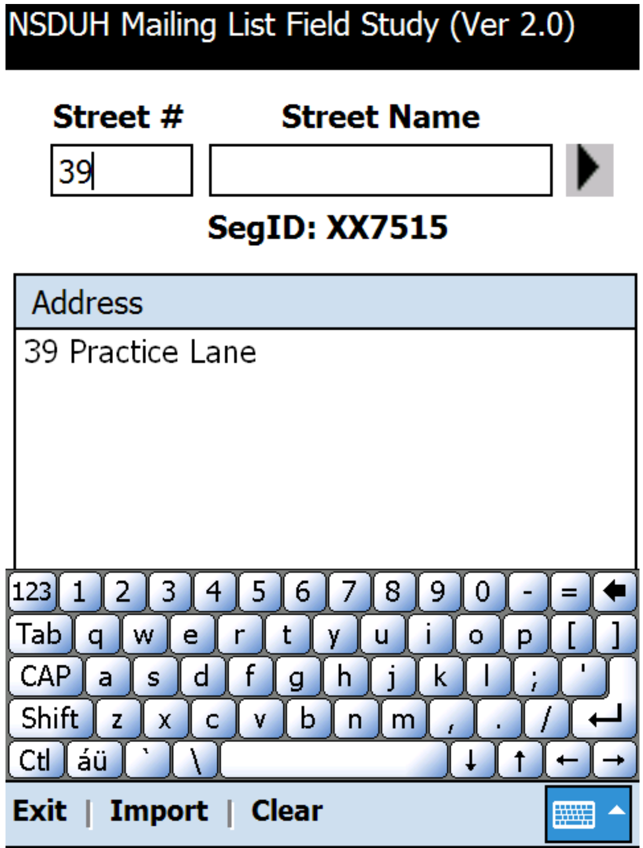
Figure 4 presents an example in which the FI performs the CHUM from the SDU "35 Practice Lane." The FI identifies the next DU as "39 Practice Lane." Instead of entering the entire address into the iPAQ, the FI enters only "39" into the "Street #" field and searches for all addresses in the segment that have "39" in the street number. The FI can then examine the list and see that "39 Practice Lane" is included.

Figure 3. Using the iPAQ to Search by Street Name

The existing protocol requires FIs to enter the full address only when the address of the next DU is not on the ABS list. Such cases will be most common in areas with low ABS coverage; therefore, the number of added addresses is a function of the ABS coverage threshold. The higher the coverage threshold, the lower the FI burden of entering missed addresses. When an FI has to add an address, he or she will not be required to enter a case-sensitive address. The address entered just needs to be enough for the FI to locate the added address if it is selected for screening.

The current CHUM procedure was recently implemented for the National Children's Study (NCS) in Los Angeles County where 42.3 percent of the housing units were multi-unit structures in 2009 (U.S. Census Bureau, 2009). This compares well with the NCS sample where a tabulation of the CDS file's secondary unit address field found that 42 percent (395 out of 939) of addresses are likely to be multi-unit structures as indicated by the presence of abbreviations such as APT, UNIT, STE (suite), or PH (penthouse). Of the 36 total field support calls received from FIs, 15 calls (42 percent) involved multi-unit structures, which was proportional to the number of multi-unit structures in the NCS sample. Although the small sample size and target population of the NCS in Los Angeles County restrict generalization to the NSDUH population, the similar call-in rates for single- and multi-unit structures offer some evidence that the amount of field support needed to support the CHUM procedure in multi-unit structures is similar to that required for single-unit structures. Based on this experience, we recommend that the CHUM training materials for multi-unit structures be revised to focus on the most common situations that FIs are likely to encounter.

Figure 4. Using the iPAQ to Search by Street Number



On projects that use ABS, RTI routinely deletes a certain number of ABS addresses from the ABS list provided to FIs as a way to monitor whether they are correctly implementing the CHUM. This "seeding" process enables us to determine how often an FI does not implement the CHUM. This also serves as an encouragement to implement the CHUM, because the FIs are told about the seeding process during training. Telling the FIs about the seeding process during training is a "trust but verify" approach that has worked well on other ABS projects. Field managers explain to the FIs that seeding is needed not only for quality control but also as a way to extend training into the field, because whenever a seeded address is missed, the FI is contacted and a review of the CHUM for the seeded address is performed. In addition, informing the FIs about seeding reinforces the importance of the CHUM and encourages them to take it seriously. To date, we have not experienced negativity or "push back" from the FIs regarding the seeding process.

4. Evaluation of the Hybrid Sampling Frame

4.1 Mailing List Field Study I (MLFS I)

We designed the MLFS I to address three research questions:

- What coverage threshold is needed to ensure that the hybrid frame provides comparable coverage of the current NSDUH sampling frame?
- What coverage threshold is needed to produce comparable prevalence estimates between persons covered by the hybrid frame and those covered by the current frame?
- What are the cost savings associated with the hybrid frame?

4.1.1 MLFS I Methods

The sample for the MLFS I comprised 3,878 screened and eligible[7] sampled DUs in a subsample of 200 NSDUH segments. Segments in Alaska and Hawaii were excluded from the sampling frame. A total of 1,725 interviews were obtained from these sampled DUs in the first quarter of 2009. The use of segments already fielded for NSDUH offered two advantages:

- The virtually complete coverage of the current NSDUH frame could be used to evaluate the coverage of the hybrid frame.
- Additional interviews were not needed to determine the eligibility of DUs and to compare prevalence rates associated with the hybrid frame with those of the NSDUH frame.

The field study took advantage of segments in which enumeration, screening, and interviewing had already occurred. This enabled us to simulate what would have happened if the ABS list had been utilized in segments above the estimated ABS coverage threshold, both in terms of field staff identifying DUs not on the ABS list and estimating prevalence rates if the hybrid sampling frame had been used.

Prior to selecting the sample for the field study, we stratified the NSDUH segments based on the expected coverage of city-style mailing addresses. The coverage estimate used for stratification was based on the ratio of the number of city-style mailing addresses to the 2007 Claritas housing unit projection. Stratification enabled us to estimate the practical implications of various coverage thresholds. We also defined a separate stratum for segments with a high percentage of group quarters (GQs) because college dormitories represent an important segment of the NSDUH target population and previous research indicates that the ABS list has limited coverage of college dormitories (Dohrmann et al., 2006). Details of the allocation and selection of the MLFS I sample are provided in Iannacchione, McMichael, Shook-Sa, Morton, and Ridenhour (2010).

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[7] An eligible DU for the NSDUH is either a housing unit for a single household or a noninstitutional group quarter where at least one civilian aged 12 years or older resides for the majority of a calendar quarter.

To develop a hybrid frame of DUs, we attempted to match the street name and number, city, state, and ZIP Code of eligible sampled DUs obtained from the NSDUH screening to a list of mailing addresses purchased from a commercial vendor. The initial matching of eligible, sampled DU addresses to the mailing list yielded 2,776 matches (71.6 percent). The weighted initial match rate was 78.5 percent. Among the 200 sampled segments, 41 had a 100 percent match rate, and 11 had a 0 percent match rate. One segment did not contain any eligible sampled DUs. Sampled DUs whose mailing address did not initially match to the ABS list were followed up with a telephone or field check to verify or correct the mailing address of the DU. In the 187 segments with a 20 percent or higher expected ABS coverage rate, corrected addresses were obtained for 440 sampled DUs, which increased the ABS match rate to 86.4 percent.

The expected ABS coverage was calculated for each sampled segment as the ratio of the estimated number of city-style mailing addresses to the estimated number of DUs. Using this method, only 15.4 percent of the NSDUH segments and 10.2 percent of the eligible sampled DUs would be subject to FE with a 50 percent ABS coverage threshold. We calculated a correlation of 0.66 between the expected coverage rate and the observed rate (defined as the number of matched addresses divided by the number of sampled DUs times 100).

The CHUM procedure was applied to the 505 non-matching sampled DU addresses to estimate the gain in coverage afforded by this portion of the hybrid frame methodology. However, it was necessary to modify the CHUM procedure in order to evaluate the coverage of NSDUH sampled DUs missed by the ABS frame. To evaluate the CHUM procedure, an ABS address was selected in the vicinity of the missed NSDUH DU and then treated as a sampled DU for purposes of implementing the CHUM procedure. If the missed NSDUH DU was picked up by the CHUM, it was considered to be covered by the hybrid frame.

DUs that are not included on the ABS list and are in segments that are above the expected coverage threshold rely on the CHUM procedures for coverage. This study utilized two processes (CHUM1 and CHUM2) to make sure that DUs not on the ABS had a chance to be included in NSDUH. Prior to fieldwork, we examined NSDUH listing maps for each sampled DU that did not match to the ABS list either initially or after the phone verification process. We determined whether each sampled DU would be covered by the Phase I CHUM procedure (CHUM1) or would rely on the Phase II CHUM procedure (CHUM2) for coverage.

The hybrid frame, which utilizes a combination of FE and the HOI, the ABS list, and the CHUM1 and CHUM2 procedures, theoretically provides 100 percent coverage of the target population. However, as with any frame supplementation method, a loss of coverage occurs when FIs do not follow the correct protocols when implementing the CHUM procedures. In an attempt to incorporate the loss of coverage because of the human error inherent in performing the CHUM procedures, we based coverage of NSDUH DUs relying on the CHUM procedures on the field results rather than the theoretical coverage that we determined from the listing maps. We expect this coverage estimate to represent a "worst-case scenario" for the coverage that the CHUM procedures can provide because FIs received less training than they typically would, were not monitored in the field, were performing multiple tasks while in the field, and were encouraged to perform all fieldwork in one trip to the segment.

In addition to comparing the coverage and prevalence estimates of the current NSDUH sampling frame and the proposed hybrid frame, we estimated the cost savings associated with implementing the hybrid frame. The costs associated with the FE portion of the hybrid frame included segment editing, field supplies, shipping of segment kits, lister training, lister labor, mileage reimbursement, miscellaneous expenses incurred in the field, field supervisor support, survey specialist support, keying of listing data, and implementation of the HOI procedure during screening and interviewing. The per segment cost of supplies, training, editing, shipping, field supervisor labor, survey specialist labor, keying, and implementation of the HOI were assumed to be the same whether a segment was urban or rural. The cost difference between urban and rural segments was in lister labor hours and mileage. Miscellaneous expenses are difficult to predict prior to the lister going to the field, so the average miscellaneous expenses per segment from the 2009 NSDUH FE effort were used to determine the per segment average.

Most estimates related to the ABS portion of the hybrid frame, particularly those for CHUM-related activities, come from RTI's experience implementing an ABS sample design for the 2008 American National Election Study (ANES) (Lupia et al., 2009). The 2008 ANES was a nationally representative sample of 5,032 addresses and 297 segments that corresponded to census block groups (CBGs). Because of the size difference between NSDUH and ANES, estimates needed to be substantially inflated and do not take into account economies of scale obtained by mass production. We tried to be conservative (erring on the high side) when scaling labor projections up to NSDUH. The per segment cost components associated with implementing the ABS and CHUM portions of the hybrid frame included the purchase of the address lists, programming and field costs related to the CHUM, and other miscellaneous expenses such as segment map production.

4.1.2 MLFS I Results

4.1.2.1 Estimated Coverage of the Hybrid Frame

Table 1 presents the estimated DU coverage for each component of the hybrid frame. Because we assume that the FE frame component has 100 percent coverage of the NSDUH sampling frame, coverage estimates increase as the coverage threshold increases because more of the segments require FE. Sampled DUs in segments determined not to need FE will rely on ABS and the CHUM.

CHUM1 coverage estimates reflect how accurately the method was implemented because perfect execution would yield total coverage. This estimate should be considered a lower bound for how well the CHUM covers DUs because the field study did not adequately represent how the CHUM procedure could be implemented in the field and therefore negatively affects the coverage estimates of the CHUM. Reasons for the negative bias include the following:

- CHUM performance was not monitored for data quality during data collection. Typically, methods are used to measure the quality of the CHUM implementation in an attempt to identify and then rectify mistakes in the field.
- Field staff received less training than they would receive for an operational implementation.
- Field staff were asked to perform multiple tasks using multiple forms. This led to some confusion as to what their task was regarding the CHUM.

- Field staff had limited field time to perform the CHUM procedure. Typically, the CHUM could be performed on return visits to the segment while the FI waited for clarification from sampling support staff.

CHUM2 coverage estimates also reflect how accurately the method was implemented because perfect execution would yield total coverage. For reasons similar to those described above, the CHUM2 estimate is also believed to be an underestimate.

Table 1. Estimated Coverage of NSDUH Dwelling Units of the Hybrid Frame

ABS Coverage Threshold = 20%

	ABS	CHUM1	CHUM2	FE	Overall
Urban	93.9%	2.5%	0.8%	1.8%	**98.9%**
Rural	71.8%	13.4%	5.3%	1.8%	**92.3%**
Overall	89.3%	4.8%	1.7%	1.8%	**97.5%**

ABS Coverage Threshold = 50%

	ABS	CHUM1	CHUM2	FE	Overall
Urban	87.3%	2.1%	0.7%	8.8%	**99.0%**
Rural	63.9%	10.8%	3.2%	15.4%	**93.4%**
Overall	82.5%	3.9%	1.2%	10.2%	**97.8%**

ABS Coverage Threshold = 80%

	ABS	CHUM1	CHUM2	FE	Overall
Urban	70.1%	1.4%	0.4%	27.2%	**99.1%**
Rural	34.9%	7.6%	2.9%	50.2%	**95.6%**
Overall	62.7%	2.7%	0.9%	32.0%	**98.4%**

ABS = address-based sampling; FE = field enumeration.

How closely the estimated ABS coverage threshold comes to predicting the actual ABS coverage will have enormous influence on both cost and coverage. If we are able to accurately predict ABS coverage, low coverage segments would always be field enumerated, and fewer segments with marginal ABS coverage would rely on the CHUM. The ability to accurately predict ABS coverage is directly related to higher coverage and lower costs. Additional research was conducted to determine the best way to predict ABS coverage *a priori* (McMichael, Ridenhour, Shook-Sa, Morton, & Iannacchione, 2010).

4.1.2.2 Estimated Bias of the Hybrid Frame

A total of 1,699 of the 1,725 persons were covered by the hybrid frame at the 20 percent ABS coverage threshold. Compared with the rest of the NSDUH frame, the 26 persons not covered were more heavily concentrated in rural areas and more likely to be older and non-Hispanic white. At ABS coverage thresholds of 50 and 80 percent, only 23 and 14 persons were not covered by the hybrid frame, respectively.

We compared prevalence estimates for a number of key NSDUH outcomes based on the current FE frame with those based on the hybrid frame. None of the differences were substantively different at the 20 percent ABS coverage threshold. Because the estimates based on the NSDUH frame and the estimates based on the hybrid frame share a large portion of their cases, these comparisons have the statistical power to declare very small differences in the overall prevalence estimates as statistically significant (e.g., 0.0002). For more information on the differences in prevalence estimates, see Morton, McMichael, Ridenhour, and Bose (2010).

4.1.2.3 Estimated Cost Savings of the Hybrid Frame

The cost estimates presented in Table 2 assume that the cost of selecting the sample of 7,200 segments is the same regardless of whether the current NSDUH frame or the hybrid frame is used. Because Alaska and Hawaii have atypical listing costs, only the 7,008 segments that fall in the continental United States are considered in the cost comparisons. Note that the cost estimates include materials development and production, field labor and expenses, editing, and indirect fees.

Table 2. Estimated Annual Cost Savings[1] of the Hybrid Frame by Coverage Threshold

ABS Coverage Threshold[2]	FE Segments Number	FE Segments % of Total	ABS Segments Number	ABS Segments % of Total	Estimated Cost Savings[3]
20%	384	5.5%	6,624	94.5%	62.3%
30%	592	8.4%	6,416	91.6%	60.2%
40%	789	11.3%	6,219	88.7%	58.3%
50%	1,076	15.4%	5,932	84.6%	55.4%
60%	1,353	19.3%	5,655	80.7%	52.7%
70%	1,632	23.3%	5,376	76.7%	50.0%
80%	2,565	36.6%	4,443	63.4%	40.1%
100% (FE Only)	7,008	100.0%	0	0.0%	0.0%

ABS = address-based sampling; FE = field enumeration.

[1] Cost savings include costs incurred after the selection of the segment and before the start of field interviewing. Costs include the half-open interval (HOI) for FE segments and the Check for Housing Units Missed (CHUM) for ABS segments. Excluded are the costs associated with the 192 NSDUH segments in Alaska and Hawaii.

[2] Ratio of the number of city-style mailing addresses in a segment to the U.S. Census Bureau/Claritas DU estimate.

[3] Compared with doing FE in all 7,008 segments.

4.2 Mailing List Field Study II (MLFS II)

The only source of under-coverage associated with the hybrid frame during the MLFS I was attributable to the incorrect implementation of the CHUM, which makes developing and evaluating a CHUM training protocol of paramount importance to help implement the alternative sampling frame. The objective of the MLFS II was to determine whether the CHUM training protocol enables FIs to implement the CHUM procedure correctly in situations they are likely to encounter in the field. Toward this end, we developed at-home and in-person CHUM training protocols as well as field exercises designed to assess the success of the training protocols. The in-person portion of the CHUM training was conducted in Research Triangle Park, NC, on July 28, 2010. The field exercises took place immediately following the in-person training on July 28 and 29, 2010. Ridenhour et al. (2010) provide details of the development and implementation of the MLFS II.

4.2.1 MLFS II Methods

To evaluate the FIs' performance in completing the CHUM, RTI staff purposively identified 70 unique start points for CHUM intervals in the area surrounding Research Triangle Park (Raleigh, Durham, and Chapel Hill, NC). These 70 unique start points were used to create 140 unique CHUM intervals. For the purposes of this discussion, the origination point of an interval will be referred to as start point, regardless of whether the interval is a CHUM2, which begins at a start point, or a CHUM1, which begins at an SDU. Our design specified that each start point would have an interval created from it that includes one or more DUs to be added to the frame and an interval created from it that does not have any DUs to be added to the frame.

The sampling statisticians determined the correct outcome by performing the CHUM for each interval created from a given start point. For intervals that were to have missed addresses, the addresses were recorded and subsequently deleted from the ABS list. The ABS list was also checked to ensure that the correct endpoint, or first address that the FI should find on the ABS list, existed. Thus, the sampling team's interval and the FI's intervals could be compared by each address we expected the FI to list. We also examined their evaluation of whether or not each address was on the mailing address list, knowing what the correct outcome was.

The purposeful construction of the intervals allowed the sampling statisticians to know the unique set of addresses that should be identified when performing the CHUM procedure from the start point as well as qualities of the interval that could be challenging to FIs. The resulting 140 CHUM intervals are mostly unique in that each one has a different combination of start points and correct outcomes. These 140 CHUM intervals, constructed from the 70 start points, provided a gold standard by which we were able to evaluate the FIs' implementation of the CHUM procedure. These 140 intervals included a variety of CHUM situations that FIs can encounter in the field but focused on the types of intervals that were found to be problematic during the MLFS I and other previous RTI studies. The 140 unique intervals were replicated across two FIs per interval for a total of 280 observations on the resulting data file.

There are several benefits of selecting 70 unique start points, each containing two intervals (one with one or more missed DUs and one without), creating 140 unique intervals. (Each interval is repeated by two FIs for a total of 280 observations for analysis.) First, it greatly minimized the field time required by RTI staff to identify and construct suitable intervals. Second, it provided replication to the analysis that allowed us to examine how much of the variability in FI performance caused by a particular interval's difficulty or type and how much results from FI capabilities. It also provided the benefit of comparing intervals with and without DUs to be added to the ABS list to determine how the presence of a missed DU affects an FI's ability to correctly implement the CHUM.

We split the 140 intervals across the two CHUM types: CHUM1 and CHUM2. One hundred of the intervals tested the CHUM1 procedure, and 40 tested the CHUM2 procedure. The resulting data file has 200 observations for CHUM1 and 80 observations for CHUM2 because of the replication of intervals. Each group of 14 start points that was to be visited by a group of four FIs was called a "circuit." Although the circuits completely cover the set of intervals used in this study, the circuits are not strata. We did not set out to create circuits when we designed this study, but we found this term to be useful as a way to refer to the set of intervals created from a unique set of start points that four FIs would visit. The statistical implications of organizing the intervals into groups, or circuits, are obtaining replication of multiple FIs completing an interval and enabling balance of characteristics such as CHUM type, DUs to be added to the frame, and difficulty level. The practical implication of organizing intervals into circuits is that fewer intervals had to be created by the sampling team and the number of FIs who would visit a single start point was minimized.

Each FI was randomly assigned to complete one circuit, or 14 of the 140 unique intervals. The expected distribution of intervals across difficulty level, missed DUs, and CHUM type is show in Table 3.

Table 3. Expected Distribution of Observations by Type of CHUM

Expected Difficulty Level	Missed DU?	Number of Scenarios[1]		Number of Observations[2]	
		CHUM1	CHUM2	CHUM1	CHUM2
Low	Yes	25	10	50	20
—	No	25	10	50	20
High	Yes	25	10	50	20
—	No	25	10	50	20
Total	—	100	40	200	80

CHUM = check for housing units missed, DU = dwelling unit.

Note: The actual distribution differed slightly from what was expected.

[1] A missed DU was present or absent in each CHUM interval.

[2] Each CHUM scenario was implemented by two FIs.

These intervals were evenly distributed across the circuits such that each FI attempted an equal number of CHUM intervals across two levels of difficulty. Because we were interested in finding ways in which the CHUM training can be improved, the selected intervals included more occurrences of difficult issues than FIs are likely to encounter in the field: 50 percent of the selected intervals are what we considered to be difficult. We utilized our prior experience with implementation of the CHUM—on studies such as the 2008 American National Election Study (Lupia et al., 2009) and the MLFS I —to inform what types of situations are typically problematic for FIs. We believe, in fact, that most CHUM intervals are fairly straightforward to resolve, although we do not have representative statistics to support this contention. For any study that utilized the CHUM, FIs' overall workloads would likely be less challenging than what they were faced with in completing their MLFS II work.

During the creation of the intervals, we documented why an interval is given a lower or high level of difficulty. In addition to difficulty level, we also equally distributed intervals that contain one or more DUs to be added to the frame, with a few minor exceptions. For the purposes of the CHUM1, half of the intervals contained at least one DU to be added to the frame, and half did not have any DUs to be added to the frame. Across all CHUM intervals, half contained at least one DU that was not on the ABS list, and half did not contain any DUs that were not on the ABS list. Although the manifestation of whether there are one or more DUs to be added to the frame differs between CHUM1 and CHUM2, the two procedures are similar from the FIs' perspective because both procedures consist of locating DUs not on the ABS list. It is critical to assess FI performance on both CHUM1 and CHUM2 because experience has shown that the type of issues FIs typically encounter in the field differ between CHUM1 and CHUM2.

RTI sampling statisticians constructed CHUM intervals to represent a range of CHUM situations that FIs might encounter in the field. It is imperative that FIs are able to implement the CHUM procedure in rural areas. In the MLFS I, both the CHUM1 and CHUM2 success rates were lower in rural areas than in urban areas, indicating that the CHUM procedure can be more challenging to FIs in rural settings. Furthermore, ABS coverage in rural areas is lower than in urban areas, so rural areas rely on the CHUM procedure for coverage much more than urban areas do. Of the 280 observations in the MLFS II, 52 were in rural areas.

According to the 2009 American Community Survey, 24.8 percent of housing units are multiunit structures (U.S. Census Bureau, 2009). FIs frequently encounter apartment buildings, and these DUs can be more challenging to CHUM than single-family DUs due to the atypical path of travel. There were 40 observations involving apartments.

In addition to scenarios in which the procedure the FI should follow is clear, there are certain situations in the field that require an FI to call field support at RTI headquarters to determine how to proceed. Because these rare situations require special instructions to maintain optimal coverage of the alternative frame, we need to make it absolutely clear to FIs when they must contact RTI headquarters. There were 80 observations where the CHUM situation required the FI to call field support for further instruction. Although most CHUM situations FIs encounter in the field do not require them to call field support, we oversampled these situations for the purposes of testing the CHUM training protocol.

Not only were a variety of CHUM situations represented in the evaluation, but we also chose these situations so that they represented varying levels of difficulty. We evaluated each CHUM interval on a difficulty scale of 1 to 2, with 1 being the easiest to implement and 2 being the most difficult to implement. Each FI was given an equal number of intervals within each level of difficulty. The variety of situations that make up the less difficult and more difficult situations was developed from our sampling team's experience providing field support for the CHUM on studies such as the 2008 American National Election Survey. Our distribution of CHUM intervals across several factors was similar to that of the MLFS I.

Because there are multiple factors that were not only represented in the overall design, but also balanced across the CHUM intervals and FIs, Table 4 presents a tabular display of the MLFS II experimental design. Each group of four FIs performed the CHUM1 or CHUM2 on a circuit, or set portion of 28 unique intervals created from 14 unique start points. Each FI had seven intervals that contained one or more DUs to be added to the ABS list and seven intervals that contained no DUs to be added to the ABS list. Each FI visited 10 CHUM1 intervals and 4 CHUM2 intervals. Because we did not want to alarm any residents with a large number of FIs visiting their neighborhoods in a short period of time, no start point had more than four FIs visit it. Each FI had seven intervals that were easy to implement, or low difficulty, and seven intervals that were more challenging to implement, or high difficulty. Five intervals of each difficulty level occurred with the CHUM1, and two intervals of each difficulty level occurred with the CHUM2. Thus, the design is balanced across difficulty level, CHUM type, DUs to be added to the frame, and occurrence of situations of interest (e.g., apartments).

Furthermore, because contamination between FIs was a concern, each FI received his or her set of intervals in an ordered sequence that attempted to minimize, to the extent possible, the likelihood of FIs completing the same intervals at the same time in the field. This concern is unique to this field test of the CHUM training protocol because in any real field implementation, FIs would be completing the CHUM for their assigned SDUs and multiple FIs would not be visiting the same DUs during the same time period.

Table 4. MLFS II Experimental Design

FI Circuit	Interval Start Point ID	CHUM Scenario Difficulty	CHUM Type 1 or 2	Phone Support Required	FI ID Number																			
					1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Circuit 1	1	Low	1	N	●	○	●	○																
	2	High	1	Y	○	●	○	●																
	3	High	1	Y	●	○	●	○																
	4	Low	1	N	○	●	○	●																
	5	Low	1	N	●	○	●	○																
	6	High	1	N	○	●	○	●																
	7	High	1	N	●	○	●	○																
	8	Low	1	Y	○	●	○	●																
	9	Low	1	N	●	○	●	○																
	10	High	1	N	○	●	○	●																
	11	High	2	N	●	○	●	○																
	12	Low	2	Y	○	●	○	●																
	13	Low	2	N	●	○	●	○																
	14	High	2	N	○	●	○	●																
Circuit 2	15	High	1	N					●	○	●	○												
	16	Low	1	Y					○	●	○	●												
	17	Low	1	Y					●	○	●	○												
	18	High	1	N					○	●	○	●												
	19	High	1	N					●	○	●	○												
	20	Low	1	N					○	●	○	●												
	21	Low	1	N					●	○	●	○												
	22	High	1	Y					○	●	○	●												
	23	High	1	N					●	○	●	○												
	24	Low	1	N					○	●	○	●												
	25	Low	2	N					●	○	●	○												
	26	High	2	Y					○	●	○	●												
	27	High	2	N					●	○	●	○												
	28	Low	2	N					○	●	○	●												
Circuit 3	29	Low	1	N									●	○	●	○								
	30	High	1	Y									○	●	○	●								
	31	High	1	Y									●	○	●	○								
	32	Low	1	N									○	●	○	●								
	33	Low	1	N									●	○	●	○								
	34	High	1	N									○	●	○	●								
	35	High	1	N									●	○	●	○								
	36	Low	1	Y									○	●	○	●								
	37	Low	1	N									●	○	●	○								
	38	High	1	N									○	●	○	●								
	39	High	2	N									●	○	●	○								
	40	Low	2	Y									○	●	○	●								
	41	Low	2	N									●	○	●	○								
	42	High	2	N									○	●	○	●								
Circuit 4	43	High	1	N													●	○	●	○				
	44	Low	1	Y													○	●	○	●				
	45	Low	1	Y													●	○	●	○				
	46	High	1	N													○	●	○	●				
	47	High	1	N													●	○	●	○				
	48	Low	1	N													○	●	○	●				
	49	Low	1	N													●	○	●	○				
	50	High	1	Y													○	●	○	●				
	51	High	1	N													●	○	●	○				
	52	Low	1	N													○	●	○	●				
	53	Low	2	N													●	○	●	○				
	54	High	2	Y													○	●	○	●				
	55	High	2	N													●	○	●	○				
	56	Low	2	N													○	●	○	●				
Circuit 5	57	Low	1	N																	●	○	●	○
	58	High	1	Y																	○	●	○	●
	59	High	1	Y																	●	○	●	○
	60	Low	1	N																	○	●	○	●
	61	Low	1	N																	●	○	●	○
	62	High	1	N																	○	●	○	●
	63	High	1	N																	●	○	●	○
	64	Low	1	Y																	○	●	○	●
	65	Low	1	N																	●	○	●	○
	66	High	1	N																	○	●	○	●
	67	High	2	N																	●	○	●	○
	68	Low	2	Y																	○	●	○	●
	69	Low	2	N																	●	○	●	○
	70	High	2	N																	○	●	○	●

CHUM = check for housing units missed, DU = dwelling unit, FI = field interviewer, MLFS = Mailing List Field Study.

Note: The actual distribution differed from what was expected.

● - Contains DUs to be added to the frame.

○ - Does not contain DUs to be added to the frame.

4.2.2 MLFS II Results

The success rate for typical CHUM intervals was 90.7 percent compared with 60.0 percent for high-difficulty intervals. Overall, FIs were able to implement the CHUM correctly in 78.0 percent of the CHUM1 intervals and 68.8 percent of the CHUM2 intervals they encountered. Important caveats should be applied to the MLFS II results. First, our analysis shows that the first three or four intervals served as a “learning curve” for many FIs: FIs implemented the CHUM correctly in 71.5 percent of the Day 1 intervals and 78.7 percent of the Day 2 intervals. If the Day 1 intervals are excluded, the success rates become 81.6 percent for the CHUM1 and 72.3 percent for the CHUM2. We also included many more difficult CHUM intervals in the field exercises than are likely to occur operationally. FIs can complete high-difficulty intervals correctly if they recognize that they need to ask field support for help. As such, these success rates should be considered a lower bound.

By comparison, the 2005 Listing Validity Study found that the HOI was properly applied more than 99 percent of the time during DU screening (Cunningham, Hunter, Justin, Morton, & Stolzenberg, 2006). The study also found that many of the problem segments were field enumerated during the first few months of the listing process, showing a possible learning curve and that apartment situations are not problematic when implementing the HOI because the path of travel has already been established during FE. These findings are in marked contrast to an experimental study by Eckman and O’Muircheartaigh (2011) that found that the HOI procedure often fails to reduce under-coverage and can introduce over-coverage in a field enumerated frame. It is difficult to compare these results directly to the NSDUH experience because numerous confounding factors are known to affect field work. For example, tenure of the field staff, quality of the training, and the priority given to the task each can change the effectiveness of the HOI and CHUM procedures. An important point common among frame supplementation quality research is that sufficient training and quality monitoring are necessary in significantly improving frame coverage.

Most FIs reported that the MLFS II FI handbook and iLearning course were very helpful in preparing them for the in-person training and presented the procedures in a very clear and straightforward manner. However, even after reviewing this information and attending the training, FIs still reported difficulty with several concepts during their field work, including

- entering the least amount of information in the MLFS Search software that produces the most results,
- performing the CHUM at apartments and trailer parks,
- sorting apartments alphanumerically,
- utilizing the maps to locate SDUs/start points and move through the segment,
- adding the SDU address to the table where the FI lists next dwelling units (NDUs), and
- identifying when to call field support (even after referring to the handbook and being asked to do so at the beginning of Day 2).

To address some of these challenges, we recommend including more time for review of the handbook and iLearning course, along with additional exercises to practice the more difficult concepts (e.g., sorting apartments) for the at-home training component. This could be accomplished by shipping the at-home training materials to FIs several days earlier, along with working with their field supervisors to ensure there is adequate time in the FIs' work schedule for this review. Utilizing this extra review time would enable FIs to absorb the content and practice with the iPAQ and procedures, thus increasing their comfort level before attending the in-person training.

During the first FI debriefing, several FIs commented that they felt like "robots" because they did not know the purpose of the CHUM. For example, they were curious about the instruction to stop the CHUM2 as soon as they encountered a DU on the ABS list. They questioned whether missed DUs might be in the unchecked portion of the CHUM2 block. Adding some background on the rationale for the CHUM could provide context for what we are instructing them to do. Finally, including the SDU address as the first line in the table where the FIs list Next Dwelling Units (NDUs) on the CHUM forms will discourage FIs from mistakenly writing and checking the SDU.

5. Operational Issues Associated with the Use of the Hybrid Frame

5.1 Predicting ABS Coverage at the Segment Level

Cost is the primary reason for developing a hybrid frame composed of ABS and FE as an alternative to the current NSDUH frame that uses only FE. To optimize between cost savings and high coverage, the strategy of the hybrid frame would be to use ABS in segments where the ABS frame coverage of DUs is adequate and to apply FE in segments where ABS frame coverage is low. This determination should be made based on the coverage properties and costs associated with using ABS and FE in a sample segment. To this end, there must be a viable method for determining which segments will be field enumerated and which segments will use ABS. Accurately predicting segment coverage is critical for using a hybrid ABS/FE frame efficiently.

The ABS coverage of a segment reflects the proportion of all DUs in the segment included on the ABS frame. The two components of coverage prediction are the number of DUs in the segment that are on the ABS frame and the total number of DUs in the segment. The number of DUs in the segment that are on the ABS frame is approximated by the number of locatable mailing addresses (LMAs) on the CDS and No-Stat files (described in Section 2) that geocode[8] into the segment. This count is obtained by classifying city-style addresses and throwbacks[9] as locatable for the purposes of this study. The total number of DUs in the segment can be estimated using census data like the American Community Survey (ACS) 5-year data or 2010 Decennial Census:

$$Predicted\ Coverage = \frac{Number\ of\ LMAs\ in\ Segment}{Estimated\ Number\ of\ DUs\ in\ Segment}$$

This method has two major sources of error. The LMA count in the numerator is subject to geocoding error. Geocoding error of LMAs can be minimized by choosing a sufficiently large segment like a CBG or census tract (for a further discussion of geocoding error, see Section 5.3). The other source of error is the estimated number of DUs in the segment that can be out of date or out of sync with what is actually on the ground. Currently, the best national DU estimate at the Census Block Group (CBG) level is the 2010 Census Redistricting Summary Files, a byproduct of the 2010 Decennial Census.

Using the 2010 Census Redistricting Summary Files to estimate the total number of DUs and LMA counts from a commercially available version of the 2011 CDS file, we calculated the coverage rate for every CBG in the United States. The DU counts include vacant units, so we use LMA counts from the No-Stat file in addition to the CDS file, which contains rural vacant addresses, drop units, and throwbacks. This coverage rate allowed us to determine how many segments, in this case CBGs, would be subject to FE under different coverage threshold rules.

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[8] Geocoding is the process of converting locatable city-style mailing addresses into geographic coordinates (latitude and longitude).

[9] A throwback is a locatable city-style address on a city carrier route that receives mail at a P.O. Box rather than the residential address per the customer's request.

The coverage threshold determines the minimum predicted DU coverage a segment must have by the CDS file to be considered a part of the ABS frame. Segments predicted to have less coverage than the specified threshold will be allocated to the FE frame, while segments predicted to have coverage above the specified threshold will be allocated to the ABS frame.

Table 5 shows the expected number of segments selected for FE by coverage threshold and State. For this table, segments are assumed to be CBGs, and their ABS coverage is estimated using the method described above. The CBGs are then weighted by their population proportion within the State and multiplied by the proportion of NSDUH segments selected within the State. This enabled us to estimate an expected number of CBGs under different thresholds, taking into account the unequal selection probabilities of segments nationally. Note that requiring at least 80 percent ABS coverage does not mean that the 5,291 ABS segments would have only 80 percent coverage. In fact, only 9 percent (480/5,291) of these segments would have between 80 percent and 85 percent ABS coverage while 50 percent (2,623/5,291) would have at least 98 percent ABS coverage.

Using Vermont to discuss and interpret Table 5, notice that it tops the list because the States are sorted by the percentage of NSDUH segments allocated to FE at the 80 percent threshold. At the 80 percent coverage threshold, Vermont would have an estimated 57 out of its 96 segments (59 percent) allocated to FE. Another way to view this could be that 59 percent of sampled segments in Vermont would have less than 80 percent DU coverage by the ABS frame and would need FE if an 80 percent ABS coverage threshold were adopted.

Table 6 shows that including the No-Stat file in the numerator of the ABS coverage rate reduces the number of segments needing FE. The 10 percentage point reduction at the 80 percent threshold is particularly intriguing because the ABS frame would account for 95 percent of the DUs in these segments. At this high level of coverage, the reliance on the CHUM for frame supplementation would be greatly reduced.

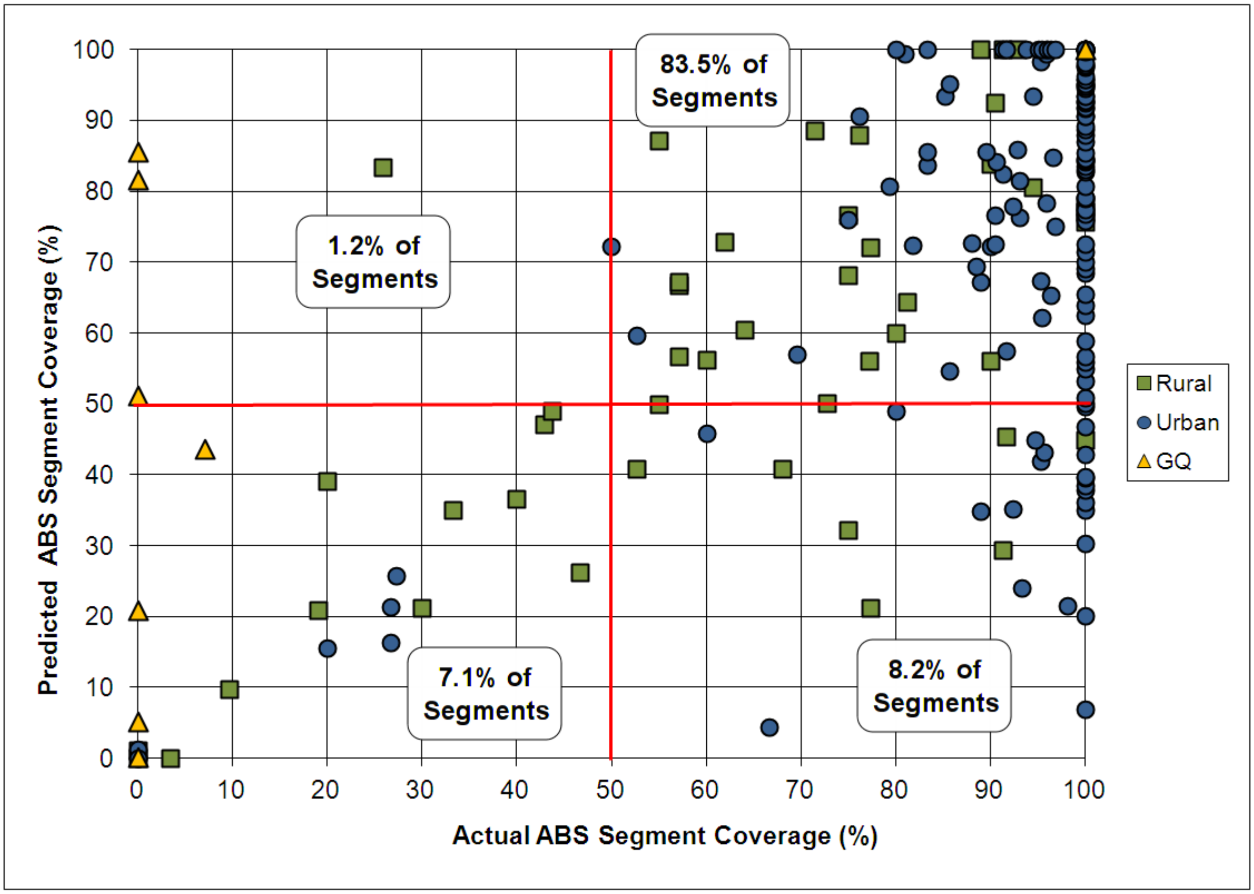
Figure 5 compares the predicted ABS coverage to the actual segment coverage for each of the 200 segments selected for the MLFS I and then evaluated actual coverage based on the results of matching the 3,878 DUs (listed via FE) to the purchased ABS mailing address list for the segments. For the purposes of this discussion, a 50 percent ABS coverage threshold is used although this same evaluation could be repeated for other coverage thresholds. Segments whose predicted coverage is above the coverage threshold of 50 percent would be allocated to the ABS frame and segments below would be allocated to the FE frame. Actual segment coverage is defined as the number of matched DUs over the total number of DUs in a segment as listed via the FE procedure. This actual coverage calculation rate assumes that FE is complete with no error.

There were four possible outcomes for each segment. Segments could be:

1. Correctly allocated to the ABS frame,
2. Correctly allocated to the FE frame,
3. Incorrectly allocated to the ABS frames, or
4. Incorrectly allocated to the FE frame.

Segments in the top right and bottom left quadrants in Figure 5 were allocated to the correct frame. Segments in the top right quadrant had ABS coverage that was predicted to be greater than 50 percent, and the actual coverage was also greater than 50 percent. Segments in the bottom left quadrant were predicted to have ABS coverage of less than 50 percent; they were also found to have actual ABS coverage less than 50 percent. All of these segments were correctly allocated to the appropriate component—ABS or FE—of the hybrid frame.

Figure 5. Comparison of predicted to actual ABS segment coverage for the MLFS I.

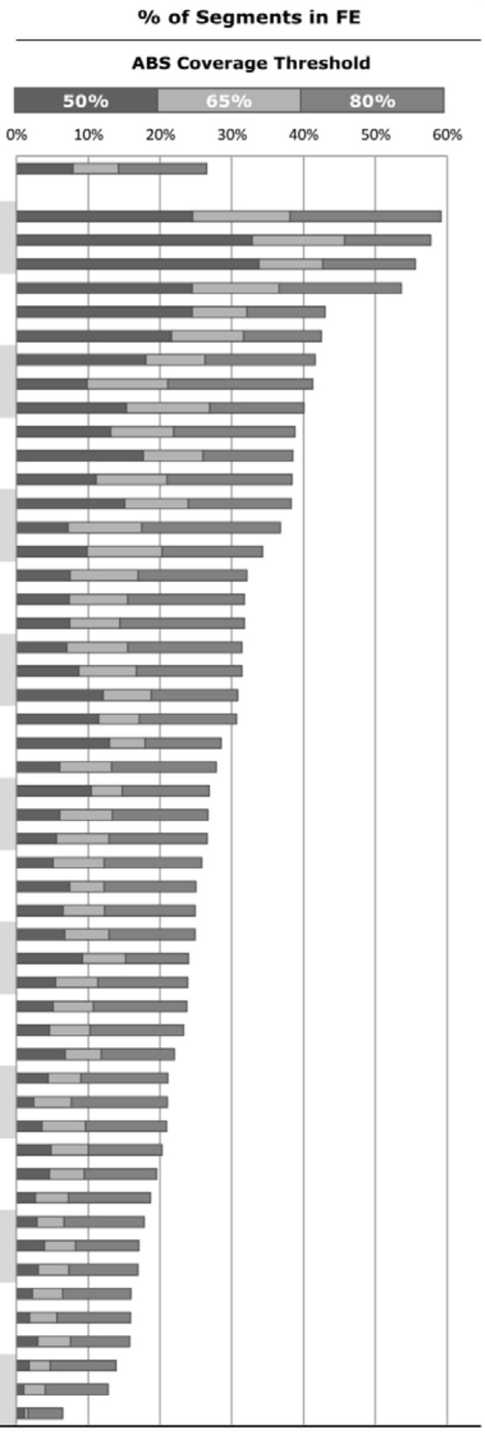


The weighted percentages in Figure 5 assume an ABS coverage threshold of 50%.

Segments in the top left and bottom right quadrants are problematic. Segments in the top left quadrant were predicted to have high ABS coverage but their actual ABS coverage was found to be lower than the coverage threshold. These segments would have incurred higher costs. Segments in the bottom right quadrant were predicted to have low ABS coverage but they were actually found to have adequate ABS coverage. Segments in this quadrant would have unnecessarily increased the costs of the hybrid frame because they were enumerated when address lists could have been utilized.

Table 5. Expected Number of Segments Selected for FE, by ABS Coverage Threshold and State

	Total Sample	Number of Segments in FE: ABS Coverage Threshold 50%	65%	80%
National	**7,200**	**568**	**1,023**	**1,909**
Vermont	96	24	37	57
Alaska	96	32	44	55
West Virginia	96	32	41	53
Maine	96	24	35	51
Wyoming	96	23	31	41
Montana	96	21	30	41
Hawaii	96	17	25	40
North Carolina	96	9	20	40
New Hampshire	96	15	26	38
South Dakota	96	13	21	37
New Mexico	96	17	25	37
Kentucky	96	11	20	37
Idaho	96	14	23	37
Mississippi	96	7	17	35
North Dakota	96	9	19	33
South Carolina	96	7	16	31
Georgia	96	7	15	30
Arkansas	96	7	14	30
Virginia	96	7	15	30
Washington	96	8	16	30
Nevada	96	12	18	30
Utah	96	11	16	29
Oklahoma	96	12	17	27
Oregon	96	6	13	27
Colorado	96	10	14	26
Florida	384	23	51	103
Louisiana	96	5	12	26
Maryland	96	5	12	25
Missouri	96	7	12	24
Pennsylvania	384	25	47	96
Minnesota	96	6	12	24
Arizona	96	9	15	23
California	384	21	44	92
Massachusetts	96	5	10	23
Alabama	96	4	10	22
Texas	384	26	45	85
Delaware	96	4	9	20
Rhode Island	96	2	7	20
Michigan	384	14	37	80
Wisconsin	96	5	10	19
Nebraska	96	4	9	19
Indiana	96	2	7	18
Illinois	384	11	25	68
New York	384	15	32	65
New Jersey	96	3	7	16
Tennessee	96	2	6	15
Connecticut	96	2	5	15
Kansas	96	3	7	15
Ohio	384	7	18	53
Iowa	96	1	4	12
District of Columbia	96	1	2	6



ABS = address-based sampling; FE = field enumeration.

Segments are assigned to FE if the ABS coverage ratio is below the specified coverage threshold.

Table 6. Expected Number of Sampled Segments Requiring Field Enumeration[1]

	ABS Coverage Threshold		
	50%	**65%**	**80%**
Without the No-Stat File	715 (10%)	1,456 (20%)	2,596 (36%)
With the No-Stat File	568 (8%)	1,023 (14%)	1,909 (26%)

[1] Total sample of 7,200 segments. Percentages shown in parentheses are percentages of 7,200 segments.

5.2 Identifying Segments with Concentrations of Group Quarters

Because ABS coverage of group quarters is problematic, segments with high concentrations of group quarters should be allocated to FE whenever possible. This section describes methods for identifying segments with concentrations of group quarters, especially dormitories that represent the majority of noninstitutional group quarters.

Previous analysis determined that a high college population indicator based on 2000 Census and 2007 Claritas[10] data corresponded mostly to having a low ABS coverage rate. A segment was considered high college population if it had (1) a dormitory percentage greater than or equal to 10 percent or (2) a dormitory population greater than 250. We examined the actual ABS coverage rate for segments in the high college population stratum for the MLFS I. When limited to segments with some group quarters population, the correlation between the high college population indicator and having an actual coverage rate of less than or equal to 20 percent was 0.77.

Using ACS data, we hoped to create a similar high college population indicator to see if we could improve the ability of the indicator to predict low ABS coverage. After reviewing the data, however, we found that the ACS reports only overall group quarter population estimates. Population estimates by group quarter type or institutional/noninstitutional group quarters are not available at the block group level.

Another approach we considered for identifying segments with concentrations of dormitories was to use data available on the Valassis CDS file. We sought to determine whether the addresses in the MLFS I that were identified as dormitories were also identified by Valassis as college addresses. However, after meeting with Valassis, our impression is that the college indicator on their file does not cover most college dormitories.

The conclusion of our investigation is that the 2010 Decennial Census is the only feasible source for predefining segments requiring FE based on having a large noninstitutional group quarters population. A high group quarters indicator based on 2010 Decennial Census data will have better predictive ability than the one based on 2000 Census data. However, as the data age, the quality of the predictor will deteriorate.

5.3 Implications of Geocoding Error on ABS Coverage

Mailing lists can be purchased by either postal or census geography. Postal geography is the geography in which USPS organizes and delivers mail. It consists of ZIP Codes and carrier or postal routes (i.e., the area within a ZIP Code where the mail is delivered by an individual

[10] Claritas, Inc. is a market research firm headquartered in San Diego, California.

delivery person). Census geography is the geography in which the U.S. Census Bureau collects and summarizes data. Census geography includes counties, census tracts, census block groups, and census blocks.

Creating area segments based on postal geography has minimal frame error because the mailing lists are already organized by postal geography. There is no error associated with assigning addresses to ZIP Codes or postal routes. However, there are limited sources of data that are released based on postal geography, which makes it difficult to append external demographic data for sample selection and weighting. Census ZIP Code Tabulation Areas (ZCTAs) were developed for the 2010 Census by the U.S. Census Bureau (U.S. Census Bureau, 2011b). ZCTAs are formed by combining census blocks within five-digit ZIP Codes. Census data are summarized at the ZCTA level and are released for the majority of five-digit ZIP Codes in the country. Because ZCTAs are released only for each decennial census however, their use is problematic for inter-censal years.

Postal geography also lacks discernable boundaries that are needed for frame supplementation procedures. Census geography allows for external demographic data to be appended and contains discernable boundaries for frame supplementation. For these reasons, ABS studies typically base area segments on census geography rather than postal geography. Table 7 summarizes the advantages and disadvantages of using postal and census geography in ABS studies.

Table 7. Postal Geography vs. Census Geography for ABS Studies

	Advantages	Disadvantages
Postal Geography	• Minimal frame error	• Limited external demographic data available • No discernable boundaries for frame supplementation
Census Geography	• Can easily append external demographic data • Discernable boundaries allow for frame supplementation	• Frame error resulting from allocating addresses into segments

One challenge that emerges from area segments defined by census geography is that mailing addresses must be allocated, or geocoded, into area segments by assigning a latitude and longitude coordinate to each address and evaluating census boundary files to determine to which segment to allocate the address. Geocoding error can occur when addresses are incorrectly allocated across area segments.

Two types of geocoding error can occur at the segment level. Under-coverage geocoding error occurs when addresses are misallocated out of the selected segment. Addresses that are present in the segment are not included on the segment’s mailing list. Over-coverage geocoding error occurs when addresses are misallocated into the selected segment. Addresses that are not present within the segment boundaries are included on the segment’s mailing list. Under-coverage error is the more serious type of geocoding error. Addresses that should be included on the sampling frame are incorrectly excluded, and the coverage of the frame is reduced unless frame-supplementation procedures pick up these excluded addresses. Over-coverage error can result in sampling inefficiencies when addresses are included on the frame that are not truly eligible for the study because they are not in the selected segment. This can result in higher ineligibility rates and increased field costs.

To examine over-coverage geocoding error, we took a sample of 1,360 addresses from the mailing list that geocoded into blocks associated with the 200 NSDUH segments selected for the MLFS I and matched them to the field-enumerated listing. It was cost prohibitive to match all of the mailing list addresses that geocoded into the selected segments to the field-enumerated listing because addresses that did not match to the field-enumerated listing through the automated matching procedure were matched manually. We stratified the sample by the urban/rural classification of the segment[11] because urbanicity was expected to be highly related to geocoding error. Addresses on the field-enumerated list were known to be in a segment and were assumed to be a complete listing of DUs contained in that segment. Therefore, if an address from the mailing list was not on the field-enumerated list, it was assumed to have incorrectly geocoded into the segment. These addresses were analyzed to determine the characteristics related to over-coverage geocoding error. They were not used to obtain an estimate of over-coverage geocoding error because they were not investigated in the field like the 3,878 screened and eligible DUs were and thus were not fully resolved.

Of the 3,878 screened and eligible DUs obtained from the NSDUH field-enumerated frame, 3,229 matched to the mailing list for an 89.6 percent weighted match rate. The remaining addresses did not match to the mailing list, were unresolved, or matched to the mailing list but were incorrectly classified as business addresses.

We examined the level of geocoding accuracy for the 3,229 FE-to-mailing-list matches by comparing the true segment, CBG, census tract, and county location of each DU to its mailing address' geocoded location. Table 8 displays the cumulative number of matches at each level of geocoding accuracy and the cumulative weighted percentage of matches geocoding at each level by urbanicity. Overall, an estimated 89.9 percent of addresses geocode into the correct segment. The proportion of addresses that geocode into the correct segment increases significantly at the CBG level, where an estimated 99.3 percent of addresses geocode into the correct CBG. This significant increase is consistent with previous research that showed higher levels of geocoding accuracy for larger geographic areas (Morton et al., 2007). This finding supports the claim that larger geographic segments should be used in ABS studies because there is minimal loss in coverage due to geocoding error beyond the CBG level.

Geocoding accuracy is much better in urban segments than in rural segments. In urban segments, 92.5 percent of addresses geocode into the correct segment, while in rural segments only 76.6 percent of addresses geocode into the correct segment. Small segment sizes in ABS studies that include rural areas can result in significant under-coverage as a result of geocoding error.

[11] A segment was defined to be rural if all of the census blocks in the segment are rural. Otherwise, if one or more of the segment's blocks are urban, the segment is classified to be urban.

Table 8. Cumulative Level of Geocoding Accuracy by Urbanicity

Level of Accuracy	Overall		Urban Segments		Rural Segments	
	Num.	Wtd. Pct.	Num.	Wtd. Pct.	Num.	Wtd. Pct.
Segment	2,689	89.9%	2,273	92.5%	416	76.6%
Census Block Group	3,186	99.3%	2,605	99.8%	581	96.5%
Census Tract	3,226	99.9%	2,619	100.0%	607	99.8%
County	3,229	100.0%	2,619	100.0%	610	100.0%

5.3.1 Modeling Geocoding Error

After exploring the prevalence of geocoding error at different levels of geographic specificity (i.e., segments, CBGs, census tracts, and counties), we then sought to determine what characteristics of addresses and segments are related to segment-level under-coverage and over-coverage geocoding error. We modeled each type of geocoding error using a logistic regression model in SUDAAN's proc logistic, which takes into account both the study design and the design weights (RTI International, 2008). The variables considered as predictor variables and their sources are listed in Table 9. Variables include both address-level variables obtained from the mailing list and segment-level variables obtained from either the 2000 Census or census projections obtained from Claritas and Geolytics. The initial models contained main effects for all of the variables in Table 9. To obtain the final model, we excluded insignificant variables and collapsed levels of variables for those variables that were significant in the model, but not all levels of the variables were significantly different.

To determine which characteristics of addresses and segments lead to higher levels of under-coverage geocoding error, we fit a logistic regression model. For each of the 3,229 screened and eligible DUs from the NSDUH field-enumerated frame that matched to the mailing list, we determined whether the mailing address geocoded into the correct segment or not by comparing the DU's true location obtained during the FE process to its mailing address' geocoded location. The binary outcome *Under-Coverage Geocoding Error* indicated whether or not each address incorrectly geocoded out of the segment.

After fitting a logistic regression model with the predictors listed in Table 9, we fit a subsequent model with insignificant predictors removed. We collapsed the area of segment, median home value, and census division variables because not all levels of these variables were significant. The final model was:

Under-Coverage Geocoding Error = Route Type, Rural/Urban, Area of Segment, New Homes, Median Home Value, Census Division

Table 9. Potential Geocoding Error Predictors and Sources

Address-Level Variables	Segment-Level Variables
Vacancy Status (Y/N)[1] Drop Point (Y/N)[1] Route Type[1] • Street • High-Rise Delivery Type[1] • Residential Curb • Residential Cluster Box Unit • Residential Central • Residential Other	Rural/Urban[2] Census Division[2] Total Number of Dwelling Units[3] • < 150 • 150 to 250 • > 250 Area (Square Miles)[2] • < 0.08 • 0.08 to 1.30 • > 1.30 Median Home Value[4] • < $100,000 • $100,000 to $300,000 • > $300,000 New Homes[4] • Proportion > National Average • Proportion ≤ National Average Percent Owner Occupancy[4] • < 35% • 35% to 85% • > 85%

[1] Mailing list classification

[2] Obtained or derived from 2000 Census

[3] Claritas estimate

[4] Geolytics estimate

Table 10 displays the odds ratios for the predictors in the final model. A number of characteristics were significantly related to under-coverage geocoding error. Addresses associated with high-rise postal routes were more likely to incorrectly geocode out of the segment compared with addresses associated with street routes. Addresses in rural segments have over two times the odds of an under-coverage geocoding error compared with addresses in urban segments. The geographic area of the segment also impacts the probability of incorrectly geocoding out of the segment, with larger segments having a higher probability of under-coverage error than smaller segments, although this is probably due to an interaction between the urbanicity of the segment and the size of the segment. Areas with a higher proportion of new homes also have increased odds of under-coverage error, as do areas with median home values of less than $300,000. Under-coverage geocoding error rates also vary by census division, with significantly higher levels of error occurring in the South Atlantic and Mountain divisions than in the other census divisions.

We fit another logistic regression model to determine which characteristics of addresses and segments lead to the highest levels of over-coverage geocoding error. For each of the 1,360 mailing addresses sampled from the mailing list that geocoded into selected segments, we determined whether or not the address correctly geocoded into the segment by matching it against the field-enumerated list. Addresses from the mailing list that were not on the field-enumerated list were assumed to have incorrectly geocoded into the segment because the field-enumerated listing was assumed to be a complete list of DUs in the segment. The binary outcome *Over-Coverage Geocoding Error* indicated whether or not each address incorrectly geocoded into the segment.

Table 10. Under-Coverage Geocoding Error Odds Ratios

Variable	Wtd. Pct.	OR	95% CI
Address-Level Variables	—	—	—
Route Type	—	—	—
• High-Rise	20.5%	2.54	(1.33, 4.88)
• Street	79.5%	1.00	(1.00, 1.00)
Segment-Level Variables	—	—	—
Rural/Urban	—	—	—
• Rural	16.7%	2.49	(1.48, 4.18)
• Urban	83.3%	1.00	(1.00, 1.00)
Area of Segment (SQ Miles)	—	—	—
• ≤ 1.30	80.5%	1.00	(1.00, 1.00)
• > 1.30	19.5%	2.36	(1.46, 3.81)
New Homes	—	—	—
• Prop. < National Average	63.0%	1.00	(1.00, 1.00)
• Prop. ≥ National Average	37.0%	1.71	(1.05, 2.80)
Median Home Value	—	—	—
• < $300,000	80.9%	2.70	(1.38, 5.26)
• ≥ $300,000	19.1%	1.00	(1.00, 1.00)
Census Division	—	—	—
• South Atlantic and Mountain	24.7%	2.18	(1.28, 3.73)
• All Other	75.3%	1.00	(1.00, 1.00)

After fitting a logistic regression model with the predictors listed in Table 9, we removed insignificant terms from the model. The delivery type and census division variables were collapsed because not all levels of these variables were significantly different. The final model was:

Over-Coverage Geocoding Error = Delivery Type, Rural/Urban, Census Division

The odds ratios for the predictors in the final model are displayed in Table 11. Three characteristics were significantly related to over-coverage geocoding error. Addresses where residents receive mail somewhere other than their curb or a centralized delivery point (e.g., in a mail slot) had significantly lower odds of incorrectly geocoding into a segment than addresses where residents receive mail in a centralized location or at their curb. As with under-coverage geocoding error, over-coverage geocoding error is more prevalent in rural segments than in urban segments. This is consistent with previous research showing that ABS over-coverage is more prevalent in rural areas (O'Muircheartaigh et al., 2009). Over-coverage geocoding error rates also vary by census division, with higher levels of error occurring in the New England and Mountain divisions than in the other census divisions.

Table 11. Over-Coverage Geocoding Error Odds Ratios

Variable	Wtd. Pct.	OR	95% CI
Address-Level Variables	—	—	—
Delivery Type	—	—	—
• Residential Curb, Cluster Box Unit, or Central	70.6%	1.00	(1.00, 1.00)
• Residential Other	29.4%	0.27	(0.13, 0.56)
Segment-Level Variables	—	—	—
Rural/Urban	—	—	—
• Rural	11.1%	2.03	(1.16, 3.55)
• Urban	88.9%	1.00	(1.00, 1.00)
Census Division	—	—	—
• New England and Mountain	24.4%	3.48	(1.62, 7.50)
• All Other	75.6%	1.00	(1.00, 1.00)

5.4 Enhancing ABS coverage with the Use of Supplemental Address Lists

Our previous research indicates that supplementing the ABS list with commercial database addresses prior to sample selection could add 2.4 percent coverage overall and 7.5 percent coverage in rural areas to the hybrid frame at the zero percent coverage threshold (Iannacchione et al., 2011). Because this research was conducted before the No-Stat file was commercially available, these estimates revealed only supplemental coverage to the CDS file alone. In addition, these estimates assume that commercial database lists would be purchased for all NSDUH segments, which would be costly. Unlocatable mailing addresses (UMAs) are clustered together primarily in areas without home delivery of mail (i.e., P.O. Box–only areas). Rather than supplementing the entire ABS list, including areas that do not contain any UMAs, a more efficient supplementation strategy would be to target only areas that contain UMAs. This targeted supplementation approach would provide cost savings by supplementing only the areas where commercial address supplementation is expected to add a significant level of coverage.

The first step to using a targeted supplementation approach is selecting the level of geography that will be used to identify segments for commercial database address supplementation. We limited the targeted areas considered for supplementation to those defined by census geography because postal geography would not allow us to identify many areas with UMAs. P.O. Boxes have their own ZIP Codes, and the physical addresses for persons receiving mail at these P.O. Boxes would not necessarily be assigned the same ZIP Code as their P.O. Box. If supplementation is limited to ZIP Codes containing UMAs, we could miss a significant number of these physical addresses. Census geography allows us to identify physical addresses in close proximity to UMAs.

We used the CDS file to identify CBGs, census tracts, and counties containing at least one residential UMA. These geographic areas are the potential geographic levels that would be used to identify and target areas for commercial database address supplementation. For example, if supplementation was performed at the county level, then all NSDUH segments within counties containing UMAs would be supplemented with commercial database addresses, while segments in counties without UMAs would not be supplemented. Table 12 shows the number of CBGs, census tracts, and counties in the United States, as well as the percentage of each geographic area that contains at least one residential UMA (and would thus be targeted for supplementation).

Table 12. Geographic Areas Considered for Targeted Address Supplementation

Supplementation Approach	Number in the United States[1]	Percentage Targeted[2]
Census Block Groups with UMAs	221,952	3.4
Census Tracts with UMAs	75,930	7.4
Counties with UMAs	3,140	71.5

[1] Number of each geographic area associated with residential mailing addresses on the Computerized Delivery Sequence file.

[2] Percentage of geographic area containing unlocatable mailing addresses (UMAs).

When selecting a targeted supplementation strategy, there is a balance between the added coverage associated with larger geographic areas and the costs associated with purchasing more supplemental addresses and combining them with the ABS. For targeted supplementation to be effective, the physical addresses associated with UMAs need to be allocated (i.e., geocoded) into the same geographic areas as their UMAs. The odds of UMAs and the corresponding physical addresses of the DUs geocoding into the same geographic area increase for larger levels of geography. However, the larger the geographic area used for targeting, the more costly supplementation would be.

Using CBGs to identify areas for targeted supplementation would be the least costly approach, but it is problematic to assume that P.O. Box–only addresses and the physical addresses associated with them will geocode into the same CBGs. The post office associated with the P.O. Boxes might geocode into one CBG, while the physical addresses of those DUs could geocode into an adjacent CBG. Expanding the targeted area to census tracts with UMAs would lead to purchasing more supplemental addresses but would decrease the chances of missing physical addresses associated with UMAs. Expanding the targeted supplementation approach to counties would lead to supplementing the vast majority of counties in the United States (72 percent). This approach would include all areas that we expect to benefit from commercial database supplementation but would be very costly due to the large amount of addresses that would need to be purchased and combined with the ABS. Less than 2 percent of addresses in targeted counties are associated with UMAs, making supplementation highly inefficient at the county level.

We used targeted commercial database address supplementation based on census tracts. Supplementing based on census tracts allows us to be confident that we are appropriately identifying areas that would benefit from commercial database supplementation, while controlling costs by not purchasing addresses in areas where we do not expect to find UMAs. Specifically, we identified areas likely to benefit from commercial database address supplementation by obtaining the addresses of post offices associated with 20 or more UMAs.[12] For each post office, we then identified the census tract that it is located in and the next closest census tract. Nationally, there were 4,308 "tract clusters," or groups of adjacent tracts thought to be associated with UMAs. With this targeted supplementation approach, all segments contained in these tract clusters would be supplemented prior to sample selection.

[12] For the sake of efficiency, we limited the frame to ZIP Codes associated with 20 or more UMAs. The requirement of being associated with 20 or more UMAs eliminated 208 post offices from the frame but covered 99.2 percent of UMAs.

For each of the 4,308 tract clusters thought to contain concentrations of UMAs, we defined a size measure (M_i) equal to the expected number of supplemental addresses included on the commercial database list in the tract cluster:

$$M_i = (UMA_i + NSU_i/(LMAs_i + UMAs_i + NSU_i + NSL_i))*CD_i,$$

where

CD_i = the number of commercial database addresses in tract cluster i,

UMA_i = the number of unlocatable mailing addresses on the CDS file in ZIP Codes associated with tract cluster i,

NSU_i = the number of unlocatable mailing addresses on the No-Stat file in ZIP Codes associated with tract cluster i,

$LMAs_i$ = the number of locatable mailing addresses on the CDS file associated with tracts in tract cluster i, and

NSL_i = the number of locatable addresses on the No-Stat file associated with tracts in tract cluster i.

We then sorted the sampling frame by State, selected a probability-proportional-to-size sample of 100 tract clusters, and purchased all of the commercial database addresses from these tract clusters (n = 342,658).[13] To determine which addresses were supplemental addresses, we matched the sampled commercial database addresses to the CDS and No-Stat files. Table 13 contains the weighted and unweighted sample counts by match status. For a sampling frame that includes both the CDS and No-Stat files, supplemental addresses would be addresses not included on either of these two files.

Table 13. Distribution of Commercial Database Address Sample, by Match Status

Match Status	*n*	Weighted *n*	Lower 95% CI
CDS Match	326,792	21,454,791	8,716,120
No-Stat Match	12,585	646,395	435,272
Supplemental Address	3,277	194,331	70,195
Total[a]	342,654	22,295,517	9,334,229

CDS = computer delivery sequence; CI = confidence interval.

[a] Four addresses were excluded from the matching process because they were incomplete.

Without the No-Stat file, we estimate that this targeted supplementation strategy would add 840,726 addresses to the CDS file alone. This estimate is in line with our expectations based on our previous coverage results that were calculated before the No-Stat file was commercially available. However, most of the addresses in the commercial database address sample that are not on the CDS file are included on the No-Stat file. We estimate that this targeted supplementation strategy would add only 194,331 addresses to the combined CDS and No-Stat files.

These results indicate that the benefits of commercial database supplementation are more limited than we expected based on our previous findings. It would not be cost-effective to

[13] The commercial database sample was purchased from Marketing Systems Group; it comprised a combined list of addresses from InfoUSA and Experian.

purchase all of the commercial database addresses from targeted segments and purge the file of addresses already included on the CDS and No-Stat files to obtain so few supplemental addresses. The most plausible explanation for these results is that the coverage gains we previously attributed to commercial database address supplementation could be achieved instead by including the No-Stat file on the sampling frame (i.e., the coverage gains from commercial databases are similar to those provided by the No-Stat file). We are exploring this hypothesis by evaluating the potential coverage gains afforded by the No-Stat file using addresses selected for the 2010 NSDUH. This analysis will provide a national coverage estimate of DUs for the combined CDS and No-Stat frame.

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