

Using Administrative Records to Improve Within Household Coverage in the 2008 Census Dress Rehearsal

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Abstract

This paper presents a method using administrative records and models to increase the accuracy and efficiency of the 2008 Census Dress Rehearsal Coverage Follow-up operation. As part of the 2008 Census Dress Rehearsal, some households will receive a follow-up interview to reduce within household undercoverage. This paper presents one statistical method used to identify households that may have incorrectly enumerated the number of people in the household. Using models built from Census 2000 and administrative records, the expected number of undercounted individuals within 2008 Census Dress Rehearsal households was calculated.

Key Words: Coverage Follow-up (CFU), Census, Statistical Administrative Records System (StARS), Undercoverage, Combining Data, Logistic Regression

1. Introduction¹

To ensure an accurate count for the United States (U.S.) 2010 Census, the U.S. Census Bureau will use commercial call center representatives to reinterview households with suspected coverage problems. This paper describes a method used to identify households with undercoverage.

Miscounting the number of persons in a household is one example of measurement error. Measurement errors occur when a true value for a survey unit is not correctly reported. Measurement error in censuses can potentially bias census counts and add to variability of the census counts over theoretical repetitions of census procedures.

Previous studies have found that a majority of the undercount in the census is a result of measurement error within responding households. Complicated living situations, confusing residence rules, and an intentional effort to conceal some household members seem to be the primary mechanisms behind within household undercoverage.

Measurement error in the census, even at low levels of geography, can impact millions of dollars of annual congressional spending and the appropriation and representation of state and federal elected officials. Thus, measurement error, and its effect on undercoverage and overcoverage, is a primary concern for the 2010 Census.

Aware of the potential problems of measurement error in the 2010 Census, the U.S. Census Bureau expects to reinterview select households to rectify any potential measurement errors. The central focus of this paper is to describe a methodology to determine which households should be reinterviewed as a part of the Coverage Follow-up (CFU) operation. This paper discusses how administrative records and modeling can be used to identify housing units with potential undercoverage.

2. Background

In this section, we review some of the previous literature and attempts at addressing within household undercoverage. We also briefly describe some of the proposed within household coverage improvement operations for the 2010 Census. We

¹ This report is released to inform interested parties of ongoing research and to encourage discussion of work in progress. Any views expressed on statistical, methodological, technical, or operational issues are those of the authors and not necessarily those of the U.S. Census Bureau.

conclude this section with a description of the Statistical Administrative Records System (StARS), highlighting how it might be used to improve within household coverage.

2.1 Within Household Coverage

Within household coverage refers to the person count within enumerated households as opposed to household coverage, which refers to the accuracy of the housing units count. By definition, within household coverage is conditional on the household-level response. Thus, within household undercoverage and overcoverage can only occur in households where at least one person responds. In household undercoverage, no one in the household responds or the housing unit is missing from the address frame.

As Cork and Voss wrote for the National Academies in 2006, one of the primary goals of the census has been to count each person once, only once, and in the right place. Within household overcoverage may occur if an individual is enumerated at multiple residences or multiple times within the same household. Within household undercoverage occurs when at least one member of a household responds, but not all people in the household are included on the household roster. In this paper, we focus on aspects of within household undercoverage.

2.2 Within Household Undercoverage Mechanisms

The mechanisms underlying measurement error within household enumeration have not been fully studied. Yet, there are two reigning theories to within household measurement error. Martin (1999) argued that measurement error in creating a household roster is the result of confusion. She found that complex living arrangements, lack of knowledge of everyone residing in the household, and complex residency rules often lead to an under enumeration of individuals within households. From this perspective Cook and Voss, (2006) provided a careful review of census residence rules, one source for potential measurement error in census enumeration. They gave suggestions for improving census residence rules and encouraged the U.S. Census Bureau to conduct ongoing research to improve 2010 census count.

On the other hand, Tourangeau et al (1997) found that measurement error was primarily an intentional effort to conceal some household members from authorities. For example, in some households, respondents may believe that complete reporting of household membership may lead to such consequences as: loss of welfare or other social service eligibility, eviction, arrest, or deportation.

Further research into the mechanisms leading to measurement error remains a fruitful area of research and is essential to reducing undercoverage in the future.

2.3 Census Efforts to Reduce Within Household Coverage Errors

The 1990 and 2000 censuses included operations to reduce within household undercoverage. The questionnaires for both censuses included questions designed to determine which households might have had an enumeration problem. Then, a trained enumerator interviewed households that failed particular edits on the questionnaire.

Both censuses used direct questions and editing rules to determine which households to reinterview. No efforts were made to compare census results to other sources. Moreover, no efforts were made to follow-up on households that may have incorrectly enumerated their household, but did not explicitly indicate they had a problem.

2.3.1 Within Household Undercoverage in the 1990 Census

The 1990 Census Coverage Edit Follow-up (CEFU) reinterviewed households that may have had a problem filling out the census form (Sheppard, 2003). People may have had problems for a variety of reasons including that the form did not have space for everyone in the household. Another major problem requiring a follow-up interview occurred when individuals indicated that they were not sure how to enumerate the entire household given the instructions on the paper form. Such problems were detected through the question:

“Did you leave anyone out of your list of persons for Question 1a on page 1 because you were not sure if the person should be listed – for example, someone temporarily away on a business trip or vacation, a newborn baby still in the hospital, or a person who stays here once in a while and has no other home?”

The response to this question, along with other responses, was used to determine which households needed a follow-up telephone or in-person interview to help correct any coverage errors. Even with the CEFU operation, Hogan (1993) found that approximately 30% of the 1990 census undercount was a result of within household undercoverage. He also found that this rate was even larger for Blacks, Hispanics, and Asian and Pacific Islanders.

2.3.2 *Within Household Undercoverage in the 2000 Census*

Similarly, Census 2000 included a CEFU operation to address within household coverage issues. This operation followed-up with respondents who indicated the household size was either greater than 6 or the respondent indicated one number for the household size but listed a different number of names in the household. Although the Census 2000 form contained room to list the names of twelve persons in the household, it only contained room to list the full demographic information for six individuals. Since the U.S. Census Bureau needed to get the full demographic information for everyone in the household, households with more than six people required a follow-up interview.

Census 2000 completed interviews with 487,265 of the 1,005,642 small households (less than six people) that were screened into the CEFU operation because there was a discrepancy between the total number of people in the household and the number of household members listed (Sheppard, 2003). The count discrepancy cases were divided into two categories. The high data defined persons category contained cases where the number of data defined individuals in the household was greater than the listed household size. Households in the high data defined category are expected to have a high propensity of overcoverage. On the other hand, the low data defined persons category contained responses where the number of data defined persons was less than the listed household size. Low data defined households are expected to have a high propensity of undercoverage. According to Sheppard, of the 487,265 completed follow-up count discrepancy cases, 322,509 were in the high data defined persons category and 164,756 were in the low data defined persons category. During the count discrepancy follow-up, the U.S. Census Bureau found 27.5% of all low data defined cases had one or more missing persons. Overall, the CEFU operation improved the accuracy of Census 2000 and reduced the differential undercoverage between traditionally undercounted groups (Sheppard, 2003). In addition to the CEFU operation, the Nonresponse Follow-up (NRFU) operation also included a question to assure that the interviewer had the correct within household count.

Census 2000 also included a Census Improvement Follow-up (CIFU) program targeted at reducing the housing unit undercount by following-up on vacant and deleted units. As a result of CIFU, 21.9% of the follow-up vacant units and 24.6% of the follow-up deleted housing units were converted to occupied units (Moul, 2003). Thus, the CIFU operation improved housing unit and person coverage. Furthermore, the CIFU operations benefited underrepresented gender, age, race and ethnic groups. The CIFU proved to reduce the overall undercount and helped to reduce the differential coverage rates across race and ethnic groups. Overall, the CIFU operation added approximately five million people to the Census 2000 count.

2.4 **Statistical Administrative Records System (StARS)**

Judson (2000) describes the StARS at the U.S. Census Bureau in detail. With special legal authorization, the U.S. Census Bureau has obtained seven person level administrative record files:

- The Internal Revenue Service (IRS) Individual Master 1040 File,
- The IRS Information Returns (1099) file,
- The Selective Service File,
- The Medicare Enrollment Database,
- The Indian Health Service patient file,
- The Housing and Urban Development Tenant Rental Assistance Certification System (HUD-TRACS), and
- The Social Security Census Numident File.

Within a secure area and with great restrictions, these files are combined and unduplicated. The result is the StARS database. Every project needing to access the StARS database must meet strict confidentiality requirements and receive approval from the U.S. Census Bureau and the IRS.

The StARS is used to improve survey and census methodology. It has been used to successfully improve modeling, calibration, and record linkage. In 2000, the Administrative Records Experiment was used to simulate Census 2000 counts with administrative records. Heimovitz (2003) reported that the aggregated county level estimates were between 97 percent and 102 percent of the Census 2000 counts. Heimovitz also reported that StARS needed improvement before producing small area estimates comparable to Census 2000.

This project uses StARS for modeling only. No data from StARS is ever copied onto any census data. The matching of census data to StARS is authorized by Titles 13 and 26 of the United States Code and only used for statistical purposes. In this project, no names, addresses, or personally identifiable information from StARS is appended to the census files.

2.5 The 2004, 2005 and 2006 Census Tests

In 2004, the U.S. Census Bureau tested some of the new census procedures in four counties: Queens County, New York; Colquitt County, Georgia; Thomas County, Georgia; and Tift County, Georgia. The 2004 Census Test included several experimental programs aimed at improving the accuracy of within household responses. Linse and Sheppard (2005) as well as Krejsa and Sheppard (2005) evaluated alternative question wording in the mailed and NRFU questionnaires to improve the accuracy of household responses. Both studies found that the proposed CFU questions differentiated the households that had coverage problems from those that did not have coverage problems. However, both studies acknowledged the need for more research into improving the question wording and increasing the discriminating power of the questions.

The experiments in the 2005 National Census Test primarily focused on five objectives (Tancreto, 2006), one of which was to “improve population coverage, by reducing omissions and erroneous enumerations.” An experiment to identify households with potential within household undercoverage used models based on administrative records to determine the expected number of missing individuals in each household. Households with a relatively large predicted number of missing individuals were reinterviewed by telephone. These reinterviews showed that the identified households were about twice as likely to result in an additional person or persons during the reinterview than the questionnaire based targeting methods. The 2005 Census test provided the first test of the administrative records modeling methodology.

We evaluated the success of the administrative records modeling process in the 2005 Census Test. We primarily looked at the added benefit of administrative records modeling to other CFU selection mechanisms. We found that housing units selected by the count discrepancy and the coverage probes were about twice as likely to find additional persons in CFU if they were also targeted by the administrative records modeling process than records selected by the count discrepancy and coverage probes alone. We also found that the probability of finding an additional person during CFU was about 0.037 for the cases that were targeted only by the administrative records model as compared to 0.019 for records that were selected by any other criteria.

In 2006, the U.S. Census Bureau tested new enumeration procedures in two sites: Travis County, Texas and the Cheyenne River Reservation in South Dakota. The 2006 Census Test included a CFU operation aimed to improve within household coverage. The CFU operation involved reinterviewing a subset of select households with an instrument geared at obtaining the correct household roster. Initial responses from the mailout/mailback operation, the update/enumerate operation, or the NRFU operation were eligible for CFU. All CFU interviews were conducted by telephone or by a face-to-face personal visit. All administrative records cases identified for CFU were conducted by personal visits.

Six different criteria were set for determining which households were selected for a CFU interview.

- **Large households** who responded by mail were reinterviewed. In general, a large household was defined as a house with over six people, although in some special cases households with exactly six people were eligible for CFU. This criterion was also used in Census 2000.
- **Count discrepancies** were given a follow-up interview. A count discrepancy occurs when the total number of persons listed in the household roster is not exactly equal to the total count of persons reported to be residing in the household. Count discrepancies were also included in the Census 2000 CEFU operation.
- Census forms include **coverage probe** questions on them. The undercoverage probe attempts to identify households where persons may have been omitted from the household count of people. The overcoverage probe attempts to identify persons who may have more than one place where they live or stay. Households that reported a potential enumeration error based on these questions were sent to CFU.
- Households identified at a high risk of undercoverage as determined through an **administrative records** based model received a personal visit follow-up interview.
- Households with **duplicates** found outside a census block and a sample of households found within a census block through computer matching were sent to CFU.
- A random sample of households that were not in any of the 5 criteria was selected as a control.

Using the random sample as a control, Krejsa et al (2007) evaluated the ability of the first four criteria to target roster errors². They reported that 1,329 households were selected for CFU as a result of the administrative records based model. Of the 1,329 selected records that were sent to CFU interviews, there were 1,216 completed interviews. As a result of those interviews, 75 households identified at least one missing person and 39 households identified at least one erroneously

² While no direct comparison was made to the duplication cases, in theory these cases are expected to produce results different than the random sample.

enumerated person. Overall, 8.8% of the households targeted in this way changed their household roster. This is compared to 3.9% (s.e 0.2) for the control group of randomly selected households.

Of the five criteria, the coverage probes, duplication, and the administrative records modeling included responses from the Nonresponse Follow-Up (NRFU) operation. Of the 1,216 completed CFU interviews identified by administrative records, a total of 786 households were initially interviewed during the NRFU operation. During CFU, 55 cases added at least one person, resulting in the addition of 90 persons (Krejsa et al, 2007). The percent of households reporting additional members from the administrative records criteria was higher than the percent of households adding to their roster selecting in the undercount coverage probe. The number of households reporting additional members from administrative records selection was also higher than the control group, which was a random sample of households not selected by any of the five criteria.

Of the responding households that were selected by administrative records modeling, the rate of making a roster change was greater for those who initially responded during the NRFU than those who initially responded in the mailout/mailback operation of the 2006 Census Test. The other CFU operations that included both mailout/mailback and NRFU responses also had a higher rate of roster changes from the initial NRFU responses than the mailout/mailback responses.

2.6 The 2008 Census Dress Rehearsal

The 2008 Census Dress Rehearsal will contain numerous operations to ensure an accurate count. Like the previous census tests, there will be a CFU operation aimed at improving within household coverage. Of the households that respond to the 2008 Census Dress Rehearsal, the CFU operation will identify and interview households with potential coverage problems.

The CFU operation is spread out through eleven waves. For the 2008 Dress Rehearsal, households are primarily selected for CFU based on their responses to the census questionnaire. However, as a part of wave 9, some households were selected for the CFU based on their modeled propensity for having undercounted individuals. If successful, this method will be in full implementation for the 2010 Census. Interviewers at a commercial call center conducted all Dress Rehearsal CFU interviews.

3. Methodology

3.1 Scope

One goal of the 2008 Census Dress Rehearsal CFU operation was to identify enumerated households that may have underreported the number of people living in their household. The specific objective of the administrative records selection component of the CFU was to determine the expected number of persons missing in each household. To do this, we built a model using Census 2000 data, Accuracy and Coverage Evaluation Revision 2 (ACE2)³ data, and StARS 2000 data. The model predicted the total number of persons who were undercounted in the household. This project did not identify specific individuals who may have been undercounted.

3.2 Model

3.2.1 Overview

Two stages of modeling were built. The first stage predicts

$$P(\text{ACE2} = \text{Yes} \mid \text{StARS} = \text{YES and Census 2000} = \text{No}),$$

the probability that each record in StARS that was not found in Census 2000 should have been enumerated in Census 2000. A simple match within households between StARS and Census 2000 revealed that StARS had many household records that were not included in Census 2000. Some of those records were for nonexistent people, some were for business establishments, some were for persons who were counted in other households, and some were for persons who should have been counted in the household in Census 2000 (census undercoverage). The first step of modeling was to predict the probability that a non-matching StARS record should have been included in Census 2000.

The second stage used the predicted probability from the first stage to estimate the total number of persons in the household who were not enumerated in Census 2000. This model, built from Census 2000 data, was then used to target households for the 2008 Census Dress Rehearsal CFU

³ The Accuracy and Coverage Evaluation was a survey, independent of Census 2000, aimed at measuring the coverage of Census 2000. Approximately 300,000 housing units were included in the ACE2 survey (U.S. Census Bureau, 2004).

3.2.2 Personal and Housing Unit Identifiers

Addresses were assigned a unique identifier called the MAFID. The unique person identifier is called the Person Identification Key (PIK). Some files may have the same person living in multiple housing units. Thus the same PIK may appear in two or more different MAFIDs. A unique record can be determined by a combination of MAFID and PIK.

3.2.3 Universe

The universe for the first-stage modeling began with all housing units that were in both Census 2000 and StARS. Every housing unit enumerated in Census 2000 was assigned a unique housing unit identifier, called the MAFID. During StARS creation, all addresses that match to the Master Address File (MAF) were assigned a MAFID. StARS records that did not match to the MAF had a blank MAFID. In this first step, StARS and Census 2000 were matched on MAFID at the housing unit level. This matching had three outcomes:

- Housing Units in the census only,
- Housing Units in StARS only, and
- Housing Units in both the census and StARS.

Our universe only included housing units that were in both StARS and Census 2000. Since this project used StARS to develop a model, covariates from StARS must have been available to perform the modeling. Thus, census only housing units were dropped. Although people in census only households may have underreported some people in their household, such housing units were out of scope, because the administrative records modeling process could not make inference to those units without the needed auxiliary data from the StARS files. Housing units in StARS only were excluded from the modeling because such undercoverage was classified as housing unit undercoverage rather than within household undercoverage. The scope of this project was limited to within housing unit undercoverage.

After matching at the housing unit level, persons were compared between the two files. The universe was further reduced to households where at least one person in the Census 2000 file matched to the StARS and at least one person in StARS did not match to the Census 2000 file. Housing units where there were no coverage differences between Census 2000 and StARS were assumed to have no undercoverage for this operation. Obviously, such households could have had within household undercoverage; however, administrative records could not be used to target undercoverage in these cases because the Census 2000 data and StARS were exactly the same. Other CFU sources were designed to identify such households in other ways. Moreover, matching households where no individuals were both in StARS and Census 2000 were presumed to have data quality concerns that would add excessive variance into our models.

The universe just described became the universe for households eligible for the CFU sample selected from administrative records modeling. According to Krejsa et al (2007), the universe for the administrative records model building contained, “Housing units in which at least one person was in the census and on the administrative records file and at least one person was on the administrative records file but not on the census response.”

3.2.4 Modeling Person Probabilities

Within matching housing units, the number of persons in the housing unit could differ between Census 2000 and StARS. Some of the records in StARS that did not match to Census 2000 should have been included in Census 2000 and some should have been excluded from Census 2000. Like all administrative files, an individual in StARS may have been at the wrong address, might not exist, and might have been a duplicate of another person at the same address.

The first model was used to determine which records in StARS should have been included in Census 2000. First, all records in StARS who matched to Census 2000 were assumed to be correctly enumerated in Census 2000. No modeling was necessary for predicting the probability that such records should have been in Census 2000. Second, if a record was in StARS, but not in Census 2000, there was a chance that the StARS record represented a real person who should have been counted in Census 2000. To determine if a record in StARS should have been counted in Census 2000, we matched those records to Census 2000 ACE2 data. The ACE2 operation was an independent census of several Census 2000 blocks used to evaluate Census 2000 coverage. The ACE2 data served as a training deck for our model. Since the ACE2 operation was in approximately 11,000 block clusters, this step reduced the size of the universe considerably.

We compared the list of households containing StARS persons who could not be found in Census 2000 to the list of ACE2 households. All households that could not be found in ACE2 were removed. Then, for those households that matched, we further matched the non-matching StARS persons within each household to the ACE2 using a matching heuristic. If the person matched, an indicator variable was set to “1.” Otherwise, the indicator was set to “0.” Thus the indicator suggested if

a StARS record that could not be found in Census 2000 should have been included in Census 2000 or not according to the ACE2.

Using logistic regression with a probit link function, we modeled the probability that a StARS record in our universe would be found in the ACE2. A stepwise model selection algorithm was used to determine which independent variables to use in the model. Considering the type of available variables, the model fit the data fairly well with a c-statistic of 68.7. The model did not include any adjustments due to clustering, nor did it include any weights.

Before variable selection, the full model contained the following categorical variables:

- ethnicity-race (ER),
- age category (AGE),
- HUD-TRACS source (HS1),
- IRS 1040 source (HS2), and
- possible other address (POA).

The ethnicity-race variable had 5 levels:

- Hispanic;
- White, Multiple Race, or Other;
- Black;
- American Indian/Pacific Islander; and
- Asian.

Each person in StARS was placed into one of five age categories: 0 to 17, 18 to 22, 23 to 64, 65 to 75, and over 76. During StARS creation, the source files for each record was noted. Because the source files feeding into StARS were not mutually exclusive, multiple source files could contribute to the same source. The HS1 variable indicated if the PIK was:

- not on the HUD-TRACS file,
- on the HUD-TRACS file,
- only associated with one MAFID on the HUD-TRACS file, or
- on the HUD-TRACS file and associated with multiple MAFIDs on the HUD-TRACS file.

The HS2 variable was similar to the HS1 variable with the exception that it pertained to the IRS 1040 file rather than the HUD-TRACS file. The POA indicated if the PIK was associated with one or many MAFIDs in StARS.

The fully nested interaction model with all interactions was initially fit. Using a stepwise variable selection technique, a more parsimonious model was fit.

3.2.5 Modeling Housing Unit Undercoverage

After the person-level modeling, each record in StARS that was in our universe was given an assigned probability that it was incorrectly missed from Census 2000 based on the ACE2. The person level file was then summarized at the household level. To summarize the person level information, the following variables were created:

- the minimum predicted probability in the household,
- the maximum predicted probability in the household,
- the mean predicted probability, and
- the number of unmatched StARS-identified records.

These variables along with an intercept and interactions between all variables formed the matrix of independent variables used in the housing unit model. The total number of undercovered individuals in the household according to ACE2 were used as the dependent variable. Thus the model predicted the total number of undercovered individuals in the household. A linear model was fit and a stepwise variable selection procedure was used to reduce the model.

3.2.6 Applying the model to the 2008 Census Dress Rehearsal

The annual StARS were created and prepared for this project. The 2008 Census Dress Rehearsal responses were also prepared. Then, these two files were joined by MAFID. The inner join between these two files was retained for further analysis. The resulting file was subset to housing units with at least one common PIK between StARS and the 2008 Census Dress Rehearsal. Lastly, all PIKs in the remaining file whose source was StARS but did not match to the 2008 Census Dress Rehearsal were kept. The final file was a list of all StARS records that were not enumerated in the 2008 Census Dress Rehearsal but were in households that were enumerated in the 2008 Census Dress Rehearsal and at least one person was in common between StARS and the census. This file represented the list of StARS “persons” who potentially could have been undercovered in the 2008 Census Dress Rehearsal.

The person level model from Census 2000 was applied to this file, giving the predicted probability that an individual StARS record should have been included in the dress rehearsal. Next the file was summarized at the housing unit level and the housing unit level model was applied. The household model predicted the total number of individuals in the household who were undercovered in the 2008 Census Dress Rehearsal. A reasonable cutoff was determined and 2008 Census Dress Rehearsal households with high values of missed individuals were sent for a CFU interview. Of the housing units that responded to the 2008 Census Dress Rehearsal about 35% fell into the universe of eligible housing units, and 0.9% were identified as needing a Coverage Follow-up interview. Overall, the administrative records process selects far fewer units than other coverage follow-up components.

4. Discussion

According to evaluations of the 2005 National Census Test and the 2006 Census Test, the modeling described in this paper effectively identifies within household undercoverage better than randomly selecting households. Nevertheless, there are opportunities for improving the models and achieving even greater efficiency. Data mining techniques such as random trees and neural networks may do a better job at identifying undercoverage than the logistic and linear models built from Census 2000 data. Although predictive, the current household model is incorrectly specified because the dependent variable is a count. A log-linear model or Poisson regression would be more appropriate for the nature of the data. Nevertheless, the current administrative records models are effective at identifying households needing a coverage follow-up interview.

As the 2005 Census Test results indicated, the overlap between administrative records modeling and other CFU targeting criteria may prove to be a powerful indicator of within household undercoverage, much more powerful than the individual CFU targeting criteria.

Certainly the ability of the administrative records modeling procedure to target households should be evaluated from the 2008 Census Dress Rehearsal. If the administrative records modeling process proves effective, it should be used in the 2010 census as a part of CFU. The administrative records modeling process described in this paper is expected to reduce the census undercount and improve the accuracy of census data.

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