Overview of Evaluations
of the 2010 Census Coverage Measurement Program

Mary H. Mulry and Tamara S. Adams[1]
Statistical Research Division, U.S. Census Bureau, Washington, DC 20233
Decennial Statistical Studies Division, U.S. Census Bureau, Washington, DC 20233

Abstract

The 2010 Census Coverage Measurement Program (CCM) will evaluate the coverage of the 2010 U.S. Census. New technologies and methods are being incorporated into the 2010 CCM to address the failure by the Accuracy and Coverage Evaluation Survey for Census 2000 to identify substantial numbers of enumeration errors, particularly duplicate census enumerations. Also, the 2010 CCM will provide estimates of components of coverage error (erroneous enumerations and omissions) separately in addition to estimates of net coverage. As the new methods add operational complexities, they particularly need to be evaluated to assure their effectiveness on the large scale of a census environment. The 2010 Census and CCM also provide opportunities for investigating new ways to improve census coverage measurement methodology. This paper contains an overview of the 2010 CCM Evaluation studies.

Keywords: census omissions, census erroneous enumerations, net census coverage, 2010 Census Program of Evaluations and Experiments

1. Introduction

Coverage measurement programs of recent censuses have identified coverage error and differential rates of coverage across race/Hispanic ethnicity groups within the population. The U.S. Census Bureau is incorporating new technologies and methods into the 2010 Census operations partly in an attempt to address coverage issues identified in Census 2000, such as duplicate enumerations and omissions. The Census Coverage Measurement (CCM) Program in 2010 will yield needed estimates of census coverage that will provide information that can be studied to determine how future censuses might be improved.

Likewise, evaluations of the Accuracy and Coverage Evaluation 2000 (A.C.E. 2000) revealed measurement errors, particularly the failure to identify substantial numbers of erroneous enumerations, including duplicates. In response, new technologies and methods are being incorporated into the 2010 CCM to attempt to address these problems. In addition, the 2010 CCM is attempting to measure census coverage by estimating components of coverage error, erroneous enumerations and omissions, separately.

An evaluation program for the 2010 CCM will assess the success of the new technologies and methods in providing more accurate data to support the various measurements of

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

census coverage. The CCM evaluations will be conducted under the umbrella of the Census Bureau's 2010 Census Program of Evaluations and Experiments (CPEX).

The eight CCM evaluation projects focus on factors that affect the error in the estimators for the component errors as well as error in the estimator for net error. Five projects evaluate the 2010 CCM and provide information on the accuracy of the CCM operations with a view to improving the census and coverage measurement methodology for 2020. An additional two projects examine expanding the CCM. One examines the feasibility of evaluating the census coverage in group quarters. The other compiles data from census processes for a more in-depth assessment of census operations that will provide insight about the causes of the errors in the census and CCM operations. The eighth project is aimed at developing a standard of comparison that can be used in future methodological studies in preparation for the 2020 Census.

2. Strategy for estimating coverage component errors

The 2010 Census Coverage Measurement Program has been designed to measure coverage error with a post-enumeration survey (PES). A PES generally is composed of two samples, the enumeration sample (E sample) and the population sample (P sample). The E sample is a sample of census enumerations designed to support the estimation of erroneous enumerations. The P sample is a sample of the population selected independently of the census and designed to support the estimation of census omissions. The members of households interviewed in the P sample are matched to the census on a case-by-case basis to determine whether they were enumerated in the census. Both the 2000 A.C.E. and the 1990 PES (Hogan 1992, 1993) used dual system estimation (DSE) to produce estimates of the population size. The A.C.E. Revision II also used dual system estimation (U.S. Census Bureau 2004).

The approach to estimating the component errors is first to obtain estimates of the net coverage error and the erroneous enumerations component of coverage error (Mulry and Kostanich 2006). Then the estimate of the omissions is obtained by observing the relationship

Net error = omissions – erroneous enumerations.

The estimate of omissions follows as

Omissions = net error + erroneous enumerations.

The estimator for the net error is the difference between the estimate of population size from the DSE and the census count.

The strategy for measuring the components of coverage error essentially involves expanding the definition of what is a correct enumeration while continuing to maintain the narrower definition for purposes of estimating net error. To improve the accuracy of estimates of net error, the implementation of the DSE has relied on balancing some of the components of error, meaning some census omissions offset some erroneous inclusions in a manner that preserved the net error estimate. Essentially this has entailed using a very strict definition for measuring correct enumerations (Hogan 2003). To be classified as a

correct enumeration, the enumeration had to be included in the correct location. Correct location was defined as the block or surrounding ring of blocks, known as the search area. Additionally, only those enumerations with complete name and responses to at least two of the characteristics collected on the census short form were eligible for matching. (The census long form also collected these characteristics.) The remaining enumerations, which are referred to as those with insufficient information (ignoring census imputations), could not qualify as correct enumerations under this strict definition, and persons so enumerated were treated as omissions. These criteria have resulted in inflated estimates of omissions and erroneous inclusions, but did not bias the estimate of net error.

An expansion of the definition of correct location permits the determination of whether an enumeration was included in the correct county, state, or even just somewhere in the nation rather than limiting correctness to only those enumerations that are in the correct small geographic area; i.e., search area. Determining enumeration status for some records that don't have complete name and at least two characteristics requires an expansion of the definition of enumerations eligible for matching in order to measure component errors. Previously for A.C.E. and PES, persons whose census enumerations had insufficient information were not eligible for matching. These enumerations would be represented as omissions if listed in the independent sample.

3. Types of errors

The processing of the E sample attempts to classify each enumeration into one of the following three categories:

- Correct enumerations that are for people in the housing unit population at their usual residence on Census Day

- Erroneous enumerations that do not represent people in the population at their usual residence on Census Day. The types of erroneous enumerations include

    o Duplicates
    o Enumerations for people not in the housing unit population
    o Enumerations not representing a person in the population (for example, pets).

- Enumerations that are not at the person's usual residence on Census Day but are the only enumeration for a person in the housing unit population.

The status of some enumerations may be undetermined. Such cases are coded as unresolved and imputations are made for them in the estimation process.

When an enumeration in the E sample is classified incorrectly, the cause arises from the four basic types of errors:
- errors in identification of duplicate enumerations
- errors in determining membership in the housing unit population on Census Day
- errors in determining the usual residence on Census Day
- errors in the geocoding of the housing unit containing the enumeration.

The basic types of errors also affect incorrect classification in the P sample but manifest themselves in different ways. The P sample determines the following for every person on its roster:

- whether the person is a member of the housing unit population on Census Day
- whether the listing for the person is in the P sample population
- usual residence on Census Day
- usual residence on CCM Person Interview (PI) Day
- whether there is an enumeration in the census at the person's usual residence on Census Day.

The search for duplicate enumerations in the E sample is comparable to the search for enumerations at the Census Day address for those in the P sample who move into the sample blocks between Census Day and PI interview day. For the P sample, errors in the identification of enumerations for the inmovers during the computerized search of all census enumerations may affect whether an enumeration is found for them. For the E sample, these errors would affect the identification of duplicate enumerations and possibly affect the classification of the enumeration in the E sample as correct or erroneous.

4. Evaluation of CCM Data Collection and Processing

A coverage measurement program relies on the accurate determination of correct versus erroneous enumerations, of Census Day residency, and of matches from the CCM independent sample to the census. The design of the 2010 CCM has attempted to address the weaknesses of the 2000 A.C.E. person interview and follow-up in identifying erroneous census enumerations and the Census Day residence of respondents in the independent sample. In doing so, the CCM PI, Person Follow-Up interview (PFU), and matching operations have become more complicated than for previous coverage surveys. Assessing the effectiveness of the new design is important to provide indications of the quality of the 2010 CCM, and also to identify where improvements can be made for coverage measurement in 2020.

The errors that will be studied fall into two major categories: data collection errors and processing errors. Both types of errors may affect the E sample and the P sample.

The potential sources of data collection error may occur during the interaction between interviewer and respondent. The major 2010 CCM data collection phases are: Independent Listing (of housing units), Housing Unit Followup, PI, and PFU. Housing Unit Followup attempts to resolve ambiguities after the census address list is matched to the results of the CCM listing, and the PFU attempts to resolve ambiguities after the people collected in the Personal Interview are matched to the census. Errors during the CCM interviews may result in errors in the collection of

- roster of residents of the housing unit
- alternative addresses
- information regarding moves into the CCM sample block cluster
- information regarding outmovers
- geocoding information.

The potential sources of processing error may occur during the computer processing or the clerical processing of the data. The major 2010 CCM processing phases are: housing

unit computer processing, housing unit matching, Person Interview computer processing, before followup person matching, after followup person matching, and final housing unit matching. Processing errors may result in errors in the identification of

- duplicate enumerations of E sample enumerations
- enumerations of persons in the P sample
- usual residence
- members of the housing unit population
- geocoding error.

The evaluation studies will focus on assessing effectiveness of the CCM interview and subsequent processing in determining the members of the household at each housing unit on CCM Interview Day and the usual residence of each household member on Census Day. The studies also will address the causes of and remedies for errors in the household membership and usual residence. In addition, the studies will focus on the effects of recall errors and reporting errors on the CCM PI and PFU.

In addition, there will be a synthesis of the results of the CCM evaluation studies combined with estimates of sampling error and information about any inconsistent reporting of variables used in logistic regression modeling from the CCM.

4.1 Data Collection Error

4.1.1 Respondent Debriefing
The Respondent Debriefing Study will address the data collection error that may be a source for errors in identifying usual residence and housing unit population membership. Also, the study will provide an early indicator of the CCM data quality.

The Respondent Debriefings for the CCM PI and PFU will provide information about the error that occurs between the respondent and interviewer regarding the roster of residents, alternative addresses, and moves. In addition, a PFU form review will be based on tape-recorded cases. The two respondent debriefing evaluations will include sending experts in residence rules and CCM procedures out into the field to accompany PI and PFU interviewers. These experts will audiotape cases they observe in the field as well as those they debrief. The taped PI cases will assist in the analysis, and the taped PFU cases will assist in the respondent debriefing analysis and the form review. A subsample of the CCM sample will be selected at random for the respondent debriefings. The sample size will not be very large, but will be large enough to support estimates for the nation as a whole.

4.1.2 Recall Bias Study
The Recall Bias Study will address the data collection error that may be a source for errors in identifying usual residence. The CCM relies on accurate collection of whether the respondents lived at the sample address on Census Day. For those who move around the time of Census Day, the respondents need to report the date they moved so CCM can determine whether they moved before or after Census Day. If they moved after Census Day, the correct location for their enumeration is their previous address, which the CCM PI collects. In addition, the CCM PI asks for the names of the Census Day residents and where they moved. If the Census Day residents moved to a group quarters, then they are in the P-sample. The reason for their inclusion is that they were a resident of the housing unit population on Census Day, but since they do not live in a housing unit on PI

Interview Day, they would not otherwise have an opportunity to be selected for the P sample.

Information about the error in reporting moving dates on the determination of usual residence will be available from the Recall Bias Study since it will interview known movers. Interviews at the households of known movers from the sample for the Current Population Survey (CPS) will be conducted at different lengths of time after the moves to enable forming estimates of the percentage that report correctly. With this information, the accuracy of the reports of moves in the CCM PI and CCM PFU may be assessed.

The study will focus on assessing the error in the residence status coding due to recall error by the respondent. The goal is to learn how long after a move, faulty recall causes respondents to misreport the date they or others in the household moved. In addition, the study will be able to assess the extent to which flawed recall of the current residents of a housing unit affects reports about the previous residents. The collection of dates of moves is very important to the CCM PI and PFU. The important information for CCM is whether the persons on the rosters lived at the sample housing units on Census Day. Recall error that places moves before Census Day when they were after Census Day or vice versa may create a bias in estimates of coverage error.

The CPS collects household rosters. If every name on the roster changes one month during the time the housing unit is in the CPS sample, we can infer that the household has moved. The timing of the change in the roster can be considered a standard of comparison for the move date since the roster is collected soon after the move occurs. The roster in the month prior to the change provides the names of the outmovers while the roster in the month of the change provides the names of the inmovers. Using selected CPS expired sample with a recent mover we can measure the recall bias associated with a change in residence status. A control sample of housing units in the CPS sample that did not have a change in roster also will be selected. In addition, some households that only had a partial change in the roster will be sampled.

The timing for the interviews is not yet clear pending the resolution of several issues, including how to obtain a sample of movers large enough to support the analysis. Ideally, to be included in the sample, the unit would need one or more movers (either whole household or individual) between February and May of the Census year and to have a complete move date collected in the CPS. We then would revisit the unit between one and ten months later and administer the PFU interview with one or more of the movers as a followup person. Comparing the move out dates between the two operations while controlling for the respondent type (self, proxy (neighbor) or within household proxy), other demographics, whether the followup person was an inmover or outmover, and length of time between the move and the PFU interview date, we could determine whether there is a recall bias associated with the collection of residence status within the PFU, and whether it increases over time, or differs by followup person or respondent type. The results from collecting residence status for the PFU would also apply to the PI and to the Coverage Followup operation in the 2010 Census.

4.1.3 Further Study of CCM Housing Units
The Further Study of CCM Missed Housing Units will provide information about errors during the data collection that result in errors in identifying geocoding errors. The CCM relies on accurate identification of geocoding error as part of the determination of the correct location for the enumeration of the residents of the housing unit.

Evaluations found that geocoding error was a problem in Census 2000 (Ruhnke 2003). The method of creating the 2010 Census address list has an additional feature of collecting Global Positioning System (GPS) coordinates for housing units during the Address Canvassing operation. Hopefully, the addition of the GPS coordinates to the address list will produce a level of geocoding error lower than that observed in Census 2000. The nature of geocoding error may be different in the 2010 Census, if it exists at all.

The goal of the study is to determine the level of error in identifying geocoding errors in the CCM and to assess the effect of the level of error on the quality of the 2010 CCM estimates of coverage error. The study will estimate the number of housing units geocoded in error to a block further than an adjacent block to its CCM block cluster. In addition, the study will estimate how many housing units were correctly coded as missing from the 2010 Census final address file but found on the Census Bureau's Master Address File. Also, the study will assess the effect of the errors in the creation of the census address list on the estimates from the CCM.

This study will use data collected in the CPEX Address Canvassing Evaluation, but will analyze it from a CCM perspective. The study will coordinate with the CPEX Address Canvassing Evaluation to assure that it collects any information the CCM evaluation analysis needs.

The CPEX Address Canvassing Evaluation obtains information about geocoding error by expanding the search area for matching the housing units coded as missed by CCM and those in the E sample not confirmed by CCM. The search area will be the tract that includes the sample block where the missed or not-confirmed housing unit is geocoded and the adjacent tracts. Both the final census list and the Census Bureau's Master Address File will be searched. Both computer and clerical matching will be part of the search. Some missed and not-confirmed units may be identified as possible matches in the search area but the clerical matching staff may be unable to resolve whether the addresses represent the same housing unit. A sample of these cases will be sent to the field so that interviewers can collect data using the CCM Housing Unit Followup form to resolve whether the missed or not-confirmed housing unit is found in the search area.

The Further Study of CCM Housing Units will conduct an analysis of the CPEX Address Canvassing Evaluation data to estimate the effect of errors in identifying geocoding error on the CCM estimates. Also, the project will produce an estimate of the percentage of missed and not-confirmed housing units that are found in the expanded search area.

4.2 Processing Error

4.2.1 Matching Error Study

The Matching Error Study will provide information about errors that occur during the computer and clerical processing of the CCM data. The processing errors include errors in the identification of duplicates of census enumerations in the E sample, errors in the identification of census enumeration for persons in the P sample, and errors in determining membership in the housing unit population and usual residence, as well as geocoding errors.

The evaluations of the coverage measurement programs for the 1990 Census and Census 2000 included assessing the error in the operation that matched the P sample to the census. In 1990 the matching error was low (Davis, Biemer, and Mulry 1992) and in 2000, the matching error was very low (Bean 2001). However, the matching operation in 2010 has more requirements because of the estimation of components of error and, therefore, is more complicated than for previous censuses.

In 2010 the Matching Error Study will evaluate the level of matching error in the clerical matching operation through an independent rematch of a subsample of the block clusters selected for the CCM sample. An expert matching team will reprocess all the data in the block clusters in the selected subsample. The results of the match and rematch will be compared and discrepancies will be resolved. Any discrepancies that cannot be resolved with the original data collected will be sent to the field for additional data collection. The CCM PFU form will be used for the followup. Once the discrepancies are resolved, the final data set will be considered the standard. Then error rates will be calculated and analyzed.

4.2.2 Administrative Records Study

The Administrative Records Study will provide information about the processing errors in the identification of duplicates of census enumerations in the E sample and errors in the identification of census enumerations for persons in the P sample.

Administrative records contain a wealth of information but also have their own weaknesses. An evaluation of the estimate of duplicate enumerations in Census 2000 using administrative records information validated that there were a large number of duplicate enumerations and demonstrated potential for improving CCM data quality in this manner (Mulry et. al 2006).

The 2010 Administrative Records Study plans to consider ways of using administrative records to improve CCM. The study will refine the 2000 duplicate identification methodology that employed administrative records and test using the administrative records database for confirmation of duplicates (Mulry et. al 2006). In addition, the study will explore whether other information would be useful to improve quality in other aspects of CCM, such as aiding in resolving some types of situations or in providing information that would aid imputation. For example, administrative records information may aid in confirming which enumerations linked in the computerized nationwide search for duplicates are the same person when the determination cannot be made in the field.

The methodology relies on an administrative records database with census-like records that the Census Bureau creates by incorporating data from several administrative records files. This database will be created in 2010. First a computer-matching algorithm will match records from the administrative records database to the census records using personal identification codes (PIKs). The PIKs are based on Social Security Numbers (SSNs) but constructed in a manner to protect privacy so that SSNs are not used in the linking. Next, census records with the same PIK will be identified. In a pair of census records with the same PIK that is linked by the process, one is potentially a duplicate enumeration. The Census Bureau's elite matching team, all with more than 10 years experience in matching, will review a subsample of the links to enumerations outside the blocks surrounding the sample blocks. Fieldwork will collect data to resolve cases that the matching team could not resolve initially and attempt to identify which one is the correct location for the person's enumeration.

The study will address whether the information in administrative records could provide a way to improve the quality of CCM data and possibly reduce the cost of CCM follow-up operations. For example, administrative records information may aid in confirming which enumerations linked in the computerized search for duplicates are the same person when the determination cannot be made in the field. The study will look for other ways that administrative records may be used to improve CCM data quality, such as reducing or augmenting fieldwork.

5. Comparison of Census History with CCM

The Comparison of Census History with CCM will provide information about the processing source of geocoding errors.

The 2010 CCM will attempt to say more about how various census operations affect coverage through estimating numbers and rates of erroneous enumerations by census operation. However, simply estimating erroneous enumerations in the final census count gives a limited picture. For example, an operation may include correct enumerations that a later operation removes. These details will not show up in the estimates of erroneous enumerations since only the last operation is on the final census file. A more comprehensive evaluation may reveal something about how errors arise from or are corrected by different census operations. Such an evaluation would take a very detailed look at the history of census operations and compare results from each operation to CCM results. Doing this nationwide or on any large scale appears infeasible for 2010, but this will be attempted on a small scale. Combining all the necessary files into a single file suitable for such a comparison for a localized area and comparing the results to the CCM would be a start to improving the evaluation of census operations using data from CCM.

The Comparison of Census History and CCM results will provide some information about geocoding error and possibly other types of E sample errors. Files from several steps of census operations for the selected areas will be merged into a single file, along with the portion of the CCM E sample and P sample person and housing unit files that cover those areas. The intended result is files containing a history of each person and housing unit from its first appearance along with the CCM data for that person or housing unit. Combining all the necessary census files into a file suitable for such a comparison for a localized area and comparing the results to the CCM will be a start to improving the evaluation of census operations using data from CCM.

Possible errors in geocoding will be revealed when housing units are added during operations or are moved into the sample block from other blocks. The results would show errors by operation with a view to improving operations in the 2020 Census.

6. Developing a Standard of Comparison

This project will attempt to construct a synthesis that consolidates all of the CCM evaluation results with other information about CCM errors in order to provide an overall picture of the quality of the 2010 CCM estimates. In addition, the synthesis will provide information about the error structure in the estimates of the components of coverage error, erroneous enumerations and omissions. Obtaining an understanding of the error

structure in estimates of the components of coverage error will aid the design of coverage measurement programs for the 2020 Census.

In addition, synthesizing the results of all the CCM evaluations will aid in the development of a standard of comparison for future research in preparation for the 2020 Census. Some evaluations of CCM seek to compare CCM estimates or detailed data to something taken as "truth." Getting something that can be suitably interpreted as truth is difficult and possibly impossible on a large scale, but can be attempted on a small scale.

Recent studies examined the error structure in components of census coverage error based on a poststratified estimator of net coverage error (Mulry 2008 2009, Spencer 2008). Previous studies have examined the error in the Census Bureau's implementation of the dual system estimator (Mulry 2007, Alho and Spencer 2005, Mulry and Spencer 1993, 1988). The types and sources of error found in the DSE also affect the estimates for erroneous enumerations and omissions. However, there are additional sources of data error in the estimator for erroneous enumerations and therefore, in the estimator for omissions. Also, the use of a logistic regression estimator for the DSE has implications for the effect of errors in the data. Most likely, the project will use a simulation methodology in the analysis of the error structure in the components of census coverage error.

7. Investigation of Methods to Evaluate Coverage of the Group Quarters Population

The 1980 and 1990 census coverage measurement programs included residents of noninstitutional group quarters (GQs) in their universe, but the methodology was not very effective in resolving the Census Day residence for this group. As a result, the 2000 and 2010 coverage measurement programs exclude all GQs and all GQ residents. This is a significant omission in the 2010 coverage measurement program, particularly for some age groups. Pilot studies during the 2010 Census could start us in the direction of truly being able to measure coverage of GQ facilities and of residents of GQs in the 2020 Census, at least for some types of GQs. The appropriate way to do this may differ by the type of GQ.

Group quarters present challenges for coverage measurement. The population is highly mobile so the residents of a particular GQ change quickly. Many times, access to residents is not permitted. When interviewers can obtain access, many GQ residents will not or cannot answer questions or provide information with adequate detail or accuracy. Because of confidentiality rules, administrators of GQs often will not provide lists of residents. Also, the census itself may have used an administrative list of GQ residents to assist its enumeration activity, so if the CCM uses the same list, independence between the census and the coverage measurement survey would be compromised.

This observational study will examine what types of experiments would aid in understanding GQ coverage problems and how best to assess them. In addition, the study will investigate whether enumeration problems vary by type of GQ. For example, college dormitories and migrant worker camps may have different challenges for census data collection. Also the study will consider whether different types of GQs need different methods to assess coverage. A combination of methods may be needed. For example,

methods that are effective for measuring census coverage in assisted living facilities probably are not effective for college dormitories.

The study will use methods such as field observations of GQ interviews in the census and other surveys, ethnographic observation, and respondent debriefing of census enumeration in some GQs. In addition, the study will investigate situations where use of administrative lists for coverage evaluation is feasible.

8. Summary

The evaluations of the 2010 CCM are designed to provide information about the basic types of errors that may affect its implementation. These studies will provide information about implementation of CCM in 2010 and form the basis for research during the preparations for the 2020 Census and its coverage measurement program.

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